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FRENCH SAILOR EMERGING FROM THE CONNING TOWER OF A SUBMARINE

The Propulsion of Ships*

A Subject that Demands Much Further Investigation

By A. T. Wall, M. I. N. A.

The object of this paper is to emphasize the necessity for experiments on the resistance and propulsion of ships, with the hope of creating some interest in the subject. The matter has been treated in a general way, and technical details have been avoided as far as possible. The necessity for experiments on full-sized ships has been realized for some time past.

That work is done on models of ships in experimental tanks is probably well known. The experimental tank, however, cannot, of itself, give all the information required to establish the science of ship resistance and propulsion on a firm basis. The limited knowledge of the science renders necessary a number of approximations, and errors are consequently introduced when estimating the resistance of a ship from her model. There is, however, no other method available. In addition, to extend our knowledge much work remains to be done with models. The co-ordination of model experimental results and observations on full-sized ships, herein advocated, would settle many doubtful points.

SHIP RESISTANCE DEDUCED FROM MODELS

The resistance to the motion of a ship is generally divided into four parts, viz., the skin, caused by the friction of the water on the surface of the vessel; the wave making; the eddy making, caused by unevenness of the surface, such as occurs with appendages; and air or wind resistance. Wind resistance depends on the above-water form of the ship.

The skin resistance of a ship form is estimated by a formula derived from experiments on plane boards. The maximum length of the boards used was 50 ft., and the maximum speed at which they were towed 8 knots. It was found that the resistance of the boards varied as the product of a coefficient, their area and a certain power of speed. The coefficient varied with the length.

In estimating the skin resistance of a model of a ship it is assumed that the curved surface is equivalent from the point of view of skin resistance to the resistance of a plane board having an area equal to that of the underwater surface of the ship and of the same length. To extend the results to lengths greater than 50 ft. it is assumed that every square foot of surface above the first 50 ft. of length has a resistance equal to that of the last square foot on the 50 ft. plank. It is also assumed that the index of the power of the speed is the same for speeds greater than those of the experiment. There may or may not be any appreciable error introduced by these assumptions, but experiments on a large scale would settle all doubts.

When models of ships are made for resistance experiments appendages are usually omitted and there is very little above-water portion, so that the wind resistance is negligible. The resistance of the model, therefore, consists of the skin and wave resistances. The total resistance of the model is measured and the skin resistance calculated. The remainder is taken to be the wave-making resistance. To this remainder Froude's Law of Comparison is applied to estimate the similar resistance of the ship. The skin resistance of the ship is estimated in the same way as for the model, so that the total resistance of the ship is obtained by adding these two together.

SHIP FORM AND PLANE BOARDS

It has been definitely established that Froude's Law of Comparison applies with great accuracy to the wave-making resistance. In spite of this, however, there is a possible source of error in estimating the resistance of the ship from that of the model in this way. The Ship Form differs in its behavior with regard to skin resistance from that of the plane board, the value of the former being greater than that of the latter, having the same length and area, and this increase is greater the fuller the form of the ship. Experiments carried out by Mr. G. S. Baker in the Yarrow tank at Teddington show that at the slowest practicable speeds models give a resistance exceeding that deduced for a corresponding plank by an amount varying from 5 to 29 per cent. Unfortunately, this increase is not the same for the ship as for the models, and it is not possible to say with accuracy what its value is for the former, although it can safely be said that it is not so great as in the model.

THE LAW OF SKIN FRICTION

In 1912 it was pointed out by Dr. Stanton that, provided a body was submerged to such an extent as to avoid the formation of surface waves and that the velocity at which it was moving was not high enough to cause cavitation, the resistance of the body will depend solely on its dimensions and nature of surface, and on the velocity, density and viscosity of the fluid. In such a case, by the application of the principle of dynamical similarity, it is possible to predict the friction and eddy making of a ship from its model. The frictional resistance per unit area of a surface is proportional to the squares of the corresponding speeds. The corresponding speeds are those such that the product of the speed and the linear dimension of the body is constant. The law is considered by many to have been definitely established, with the result that they say it is the only safe one to use for resistance experiments on dirigible balloons, submarines and torpedoes. It would be necessary, in order to determine the resistance, say, of a submarine submerged at 10 knots, to drive the model on a scale of one-tenth the full size, at 100 knots, and the force required to drive the model at this speed would be the same as for the full-sized submarine at 10 knots. This is at present impracticable, and therefore the ordinary method is used for computing the resistance of submarines from model experiments.

The Froude Law of Comparison is applied to wave- and eddy-making resistances, although the eddy-making resistance per unit area of a full-sized ship may be from 10 to 15 per cent. different from that of the ordinary sized model used in Tank experiments. In consequence the application of the Law of Comparison to eddy-making is not strictly correct, although the error involved must generally be a small one.

In the discussion on Mr. Baker's paper read at the North-East Coast Institution of Shipbuilders and Engineers in 1915 it was generally agreed that there was a great need for verification of the elaborate and interesting work Mr. Baker had done on surface friction of models by means of full-sized experiments. After reading the paper, one was forced to the conclusion that much experimental work had yet to be carried out before our knowledge of the skin resistance of ships was placed on a correct basis.

This matter also received attention in a paper by Dr. Lees, read before the Institution of Naval Architects in 1916. He stated that the subject would be put on a much firmer basis when data for boats of intermediate sizes had been secured by measurements made on submarines 100-200 ft. long towed under-water. In the discussion that followed this paper, Professor Dalby stated that there was a need for additional data derived from experiments with ships of large size in order to get better correlation between actual resistances and the resistances deduced from models. Such data would enable a better interpretation of the model results to be made. He stated that a large liner or a powerful battle cruiser should tow a series of ships of modern dimensions, in order to definitely establish what are the resistances of long ships at different speeds.

APPENDAGES

Appendages cannot be avoided in any ship. It is commonly accepted that Froude's Law of Comparison does not apply to these. Models are usually tested without any appendages. Should they, however, be fitted to scale on the model, the increase of resistance found is always considered to be appreciably in excess of the increase for the ship. In estimating the resistance of a ship that of the appendages is usually neglected, although the appendage resistance may be as much as 15 per cent. of the total, or even more.

AIR RESISTANCE

When the trials of a ship are run on the measured mile a time is chosen, if at all possible, when wind to any great extent is absent. Practically little or nothing is known of the air resistance of the exposed parts of a ship, although in the Seventies Mr. W. Froude made some experiments with the *Greyhound*, a ship 172 ft. long, and found that at 10 knots, and with masts and rigging absent, the air resistance was about 1½ per cent. of the water resistance. In modern merchant vessels, especially those carrying large numbers of passengers, the great amount of top structure causes this figure to be much greater.

When the initial work was being carried out for the *Mauretania*, a self-propelled model of the ship, 47 ft. 6 in. long, was experimented with. Particular attention was paid to the effect of wind on the model to ensure the accuracy of the speed results. Comparative tests showed that the mean power required, with a wind of 18 knots velocity, was over 20 per cent. higher than in calm weather.

Some idea of the wind forces may be gained from the fact that the *Mauretania*, when travelling at 25 knots, would require about 12 per cent. more power against the wind of 25 knots than in calm weather.

Air resistance is generally considered to be relatively more important in slow speed vessels than in high speed ones. It would therefore be instructive if some experiments were carried out on this matter, since it has been estimated that 80 per cent. of the ships of the Mercantile Marine are of low power and full form.

RESISTANCE AT SEA

The resistance of a ship in rough weather is greater than in smooth. To a large extent it depends on abolute size. Pitching and rolling considerably affects the speed of a ship at sea. When a ship pitches violently her speed decreases rapidly. Pitching exaggerates nearly all causes of speed loss. Not only is the resistance rapidly increased, but racing is caused, the propeller loses efficiency and more water goes on board. At the present moment there is only one safe line to follow in allowing for the effect of rough water upon speed, that is, to allow a reduction in speed from smooth water trial conditions to rough water service conditions, based upon actual experience with previous similar vessels. A good deal might be done in this direction by observation of full-sized ships, more particularly if the trials were carried out with the vessel in a condition somewhat approximately to that which she runs at in commission.

Mr. R. E. Froude has carried out some experiments on models in artificial waves. The effect upon resistance of varying the longitudinal distribution of weight was very marked. It became greater the more the weights in the model were carried towards the ends.

OBSERVATIONS ON SHIPS AT SEA

Although our actual quantitative knowledge of the resistance of ships in a seaway is small, it would appear safe to assume that the laws of resistance and propulsion apply generally for a ship in a seaway. Quantitative values can only be properly determined by model experiments, and these results can be used and are used, in a few instances to analyze the results obtained for the ship in a seaway. Much more can be done in this direction. The speed of a ship in service is on the average fairly constant, and can be ascertained from the log. The draughts of the vessel on departure and arrival are also recorded there. This is all the information usually obtainable. These figures of themselves are of little value. To render the information really useful, systematic observation of the horsepower would have to be made, and it would be still more valuable if the actual thrust on the propeller was also measured. In the ordinary way, with the multi-ring thrust block this is a difficult operation although it has been carried out in some cases. Thrust pressures have been determined with a turbine installation, the shaft horsepower being nearly 25,000 on one shaft, giving a steady thrust of over 70 tons. In this connection the Mitchell thrust block was used. By a very simple addition it is possible to measure the total thrust.

PROPELLERS

In model experiments the propeller is almost invariably run in water which has not been disturbed by the passage of a ship through it. With a propeller driving a vessel it is, of necessity, running in disturbed water. In the model experiment it is assumed that the power used up by the propeller is identical for the same thrust and revolutions, whether the propeller is running in disturbed or undisturbed water. This is very nearly true, but the variations may be as much as 5 per cent. in ships of full form.

*A paper read before the Liverpool Engineering Society. Reproduced from *The Shipping World*.

WAKE FRACTION

When a ship is moving she imparts a certain forward motion to the water immediately surrounding her, so that the propeller is moving forward with the ship in water which has a certain forward velocity itself. This forward velocity of the water round a propeller is usually expressed as a percentage of the ship's speed, and called the wake fraction. This wake fraction naturally influences the performance of the propellers, and to design a propeller successfully its value should be known. Here, again, a great deal of information is not available. Its value can only be determined by progressive trials carefully carried out and properly analyzed.

THE LAW OF COMPARISON

After experiments have been made on the model the Froude Law of Comparison is applied to obtain the results for the full-sized propeller. Some investigation on this matter would be of considerable assistance. The thrust does not in all cases vary with the square of the speed. It varies at a greater power than the square of the speed for narrow blades, and in the reverse way for wide blades. The effective pitch of a propeller varies with the speed of advance, and this of course would explain variations in efficiency.

PROPELLER PITCH

A propeller is machined with a certain face pitch, but it is always found in practice that this does not represent the working or effective pitch. This latter proves to be a very uncertain quantity. It is usually taken at any speed of advance as being that at which the propeller gives no thrust. Sir Archibald Denny, however, considers this to be incorrect. Mr. R. E. Froude adds 10 per cent. to the face pitch of model propellers to obtain effective pitch, and 2 per cent. in full-sized propellers. Mr. G. A. Baker considers that the latter figure for propellers driven at high speeds, as with turbines, should be 4 per cent. Sir Archibald Denny further considers that the relation between the effective and face pitch varies with width and shape of blade, with its thickness and width, and with non-symmetry of the blade about its center.

All these factors make for uncertainty in propeller design, and probably account for the bad performance of some propellers which frequently disappoint designers. The necessity for full-sized experiments on propellers is, therefore, very marked.

EFFICIENCY OF PROPULSION

Observations on the full-sized ship show that the propulsive efficiency may be as much as 15 per cent. different from that obtained synthetically from the model results. Further, the variation of this coefficient with apparently somewhat similar ships is remarkable, and careful judgment is required in using it. The inability to predict the propulsive efficiency of a ship from those obtained by model experiments makes it necessary to determine the value from speed and horse-power observations of similar ships.

Two things go to make up economical propulsion. One is low resistance of the hull, and the other good propulsive efficiency.

TRIAL ANALYSIS

A good deal of information can be obtained from a progressive trial carried out and properly analyzed. With warships it is easy to load them down to a draught practically the same as the average in service. With merchant vessels, excepting special types, such as Channel steamers or very high-speed passenger liners, it is not easy to obtain a draught as great as that in service. To do so the ship would have to be loaded with a large amount of cargo before being taken on the measured mile. This involves delay and expense, and in consequence, if trials are run at all, they are carried out at such light draughts as to make the results of little value.

From the results some idea, although only a rough one, may be obtained of the wake fraction of a ship, and the effective pitch of the propeller. These can, however, only be determined relatively to one another. In any case, to make the most of the results, information should be available for the resistance of the ship, and the performance of the propellers reduced directly or indirectly from model experiment.

CONCLUSION

To increase our knowledge of ship resistance and propulsion, a vast amount of work remains to be done. Experiments on the wake fraction, as already begun by Mr. Luke, should be obtained. The study of propeller problems opens up a large field for research. The last word has by no means been said on cavitation in propellers. Information can be obtained on all these matters by model experiments. Experiments on full-sized ships are naturally expensive, but to clear up the present doubts on surface friction and eddy-making resistances, something of this nature should be done.

Some effort should be made to compare the performance of ships at sea and in still water. In many cases two vessels of similar size and loading may give the same speeds for the same horse-power on trial in smooth water, and yet at sea give quite different results. Above water form probably has something to do with these differences, as well as the longitudinal distribution of weights.

A step in advance can more easily be taken now than a few years ago. With turbines the torque on the shaft is uniform, and instruments are available for measuring the shaft horse-power delivered to the propellers. In addition, it is not difficult to measure the thrust on a propeller shaft by means of an additional fitting on the Mitchell thrust block. These two measurements alone would be of considerable value. When a set of sister ships is laid down a great deal of expense would not be involved in varying different items, whose effects on resistance and propulsion are at present uncertain.

It must always be remembered that cheapness in cost of building is not the only—nor, indeed, the primary—consideration in the construction of a ship. Anything which improves the earning capacity of a vessel is cumulative in effect.

Dr. Johnson on Aeronautics

By W. H. Thorpe

At a time when the art of aviation attracts so much attention, it may be of interest to recall that Dr. Johnson was perhaps the first to state with accuracy the principle involved in any successful effort with "heavier-than-air" machines. How it happened that he, who had but a casual acquaintance with the science of his time, directed his attention to this matter, it is now impossible to say. Many attempts had been made by enthusiasts to solve the problem during the Middle Ages. Leonardo da Vinci and Roger Bacon, later Borelli and Hooke, had studied the subject and made proposals, and there had been consideration of "lighter-than-air" methods, but nothing seems to have been done immediately before Dr. Johnson's speculations, which may be thought to account for his interest in the question.

In 1759, to raise money for payment of charges consequent upon the death of his mother, he wrote "Rasselas, Prince of Abyssinia," a remarkable book telling of a quest for happiness. The story relates that before starting on his travels with this object, the prince, amongst other devices to relieve *ennui*, had consorted with men of learning and skilled exponents of various arts; amongst these, a mechanical genius, referred to as the "artist," who, to provide amusement for his patron, suggested an attempt at flight, and in discussing the matter says: "He that can swim needs not despair to fly; to swim is to fly in a grosser fluid, and to fly is to swim in a subtler." Then follows this enunciation of principles: "We are only to proportion our power of resistance to the different density of matter through which we are to pass. You will be necessarily upborne by the air, if you can renew any impulse upon it faster than the air can recede from the pressure." This is a remarkable statement, having regard to the state of knowledge at the time—159 years since. It correctly defines the principle underlying "heavier-than-air" aviation.

Dr. Johnson's was a mind extraordinarily active, and not to be deterred from addressing himself to a strange subject by its strangeness merely, so that no great surprise need be felt that he should consider this, but only that he should have made so illuminating a pronouncement with respect to a branch of study alien to his usual pursuits. By a Newton, or a Cayley, it might, most probably would, have been stated with more of mathematical precision and effect, but not more truly. It is not improbable that Johnson, mingling with the intellectuals of his time, got the idea, expressed so well, from one of these, but there is no evidence of this, and we need not question but that this naturally vigorous intellect was well able to go straight to the root of such a matter, even though it might be on ground unfamiliar to him. On the other hand, he may not himself have fully realized the truth of the statement, a supposition countenanced by other theories advanced by the "artist" of a much less acceptable nature.

It is of interest to note that the prince is described as having given his consent to the experiment, the mechanic stipulating that his invention should be kept secret for reasons which must appeal to us today. He says: "If men were all virtuous, I should with great alacrity teach them all to fly. But what would be the security of the good, if the bad could at pleasure invade them from the sky? Against an army sailing through the clouds, neither walls, nor mountains, nor seas, could afford any security. A flight of northern savages might hover in the wind, and light at once with irresistible violence upon the capital of a fruitful region that was rolling under them."

The narrative may be read with advantage, but it may be said that the "artist," notwithstanding his grasp of the fundamental principle, made the attempt with wings fitted to his own shoulders—and failed.

Later in life Johnson appears to have been attracted by the attempts of the balloonists. The Montgolfier brothers were experimenting in 1783, and on September 29, 1784, the doctor wrote to a friend that he had received three letters in one day about "the air balloon," probably referring to the ascent of Luanardi (secretary to the Neapolitan Ambassador) in London, on the 15th of the same month.

In this letter the writer seems rather to slight the effort, remarking that lack of directing power would render balloons useless for transport, and that unless able to rise above the highest mountains (which had not been done), useless as a means of extending knowledge of the upper air.

In October of the same year, with reference it is to be supposed to some mishap, the doctor wrote: "The fate of the balloon I do not much lament, to make new balloons is but to repeat the jest again. * * * The first experiment, however, was bold, and deserved applause and reward. But since it has been performed, and its result is known, I had rather now find a medicine that can cure an asthma."—*Engineering.*

Treatment of Frozen Potatoes

The severe winter weather in France has caused considerable trouble in the way of freezing of potatoes, for the temperature fell much below the normal, so that the usual precautions became insufficient to preserve the potatoes from the effects of the cold. In the case of freezing, the potatoes must be dried as soon as possible in order to prevent them from rotting after they thaw out, for this occurs very rapidly. While such a drying process might not be practicable in large centers because of the fuel that would be consumed, it can be carried out economically upon the farm by using an out-oven such as is usually to be found here, even though such ovens may be little used in later times. This method is in fact not a new one, for it was employed for instance in Brittany during the winter of 1894-95 and in other places. The oven is heated in just the same way as for bread baking, and when the proper heat is obtained, put in the potatoes (the largest can be cut up) and spread them so as to form a layer from four to eight inches thick, or enough to provide for a good evaporation of the water through the oven door, which is left open. Rake over the mass with a suitable bar in order to aid in the evaporation. When the drying is complete, the potatoes become as hard as wood. The dried potatoes should be stored in a dry place, preferably on a wood floor or on shelving. In order to use them, boil up with enough water to make a soft mass such as would be obtained in the natural state, and this can be used at least as food for stock, if for no other purpose. As regards food value, it is, of course, understood that the drying process does not remove any of the nutritive elements from the potato.

An Unusual Exhibition of Spider Webs

Notwithstanding the fact that a spider web is so fine and delicate that unless covered with dust or sparkling with dew it is almost invisible, the American Museum of Natural History, New York, is now displaying a series of these webs, 12 in number, so mounted on dark backgrounds as to be plainly visible. The spiral construction, widening gradually from the center outward, is easily traced. The webs are accompanied by colored plates of the spiders which spun them. Some spiders live in the web they spin; others spend only the nights there, hiding during the days in retreats often some distance away, with a single thread leading to the web. One of the larger spiders, *Aranea trifolium* for instance, spins a thread from the center of its web to a tent made of leaves and silk. Sitting in this tent, the spider holds the thread in such a way that it knows when the web is shaken by its insect prey.—*The American Museum Journal.*

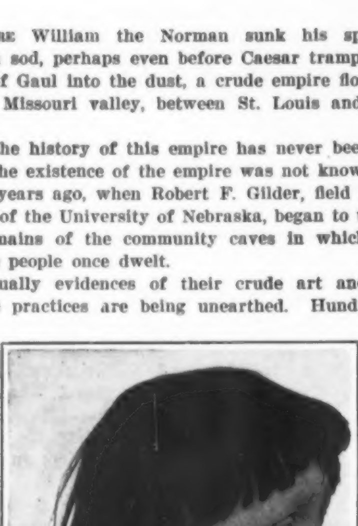
Cave Dwellers of the Missouri Valley

A Mysterious Race of Undetermined Origin

BEFORE William the Norman sunk his spurs in English sod, perhaps even before Caesar trampled the heart of Gaul into the dust, a crude empire flourished in the Missouri valley, between St. Louis and Sioux City.

No, the history of this empire has never been written. The existence of the empire was not known until a few years ago, when Robert F. Gilder, field archaeologist of the University of Nebraska, began to uncover the remains of the community caves in which these strange people once dwelt.

Gradually evidences of their crude art and their strange practices are being unearthed. Hundreds of



An alleged pre-historic cave-dwelling cannibal. Reproduced at the University of Nebraska

specimens of their implements, their sculpture, their clay modeling, their ornaments, and the combs with which they groomed their coarse hair, have already been uncovered and are now in the museum of the Omaha Public Library, and Eastern museums.

But who were these people, so much above the modern Indian in arts and sculpture?

Why did they construct their caves in perfect rectangles always averaging 20 by 40 feet in dimensions? How, indeed, did they remove the great volume of earth necessary to construct such a cave from four to seven feet deep?

Why did they devour each other in a fertile valley where bison were abundant, as is shown by the fossil remains of bison shoulder blades and other bone implements of the caves?

Where did they learn to sculpture? What implements or delicate tools did they use to carve out the soapstone busts with exquisite detail, though no more than three-quarters of an inch in height?

Who taught them the astronomy and mathematics that made it possible for them to build every cave in a perfect rectangle and lay it exactly square with the compass?

Did they come up from Mexico in the eleventh century, a peace-loving and partly cultured people, driven forth by the famine and the fiercer tribe of war-like Aztecs?

Several universities are seeking to solve this mystery through the aid of the meager circumstantial evidence found in the deep, dry caches of the cave ruins. The University of Nebraska has worked for years on the subject. The Peabody Museum of Harvard University has for the past several years sent a quiet expedition each year to work tirelessly through the summer gathering what material can be found on the subject. Both last summer and the summer of 1916 a Peabody expedition labored throughout the valley under the head of Dr. Frederick H. Stearns, director of the Peabody Museum. Over 1,000 pounds of material has been collected. This is to be washed, cleaned, studied and classified at the home museum, where each year the collection is to be added to until science will be able to give to the world some definite statement as to who and what this race was.

There are still conflicting theories as to the time in history when this race flourished. By some it is believed they inhabited the valley between 2,000 and 4,000 years ago. By others it is held that they must have been in the valley as late as the tenth or eleventh century.

In support of the first theory it is pointed out that from two to four feet of black soil has accreted on the surface of the ground over the fallen cave roof. Darwin once made an experiment in a secluded spot to learn how fast soil would accumulate from falling vegetable mould. He found that less than an inch accumulated in thirty years. Rapid calculation will then show that a great lapse of years must have taken place to allow four feet of such soil to accumulate.

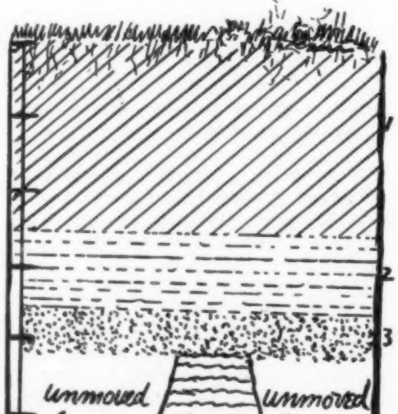
Again, oak trees four hundred years old have been found growing squarely over what was once the cave site.

A pink soapstone head less than an inch in height, now in the museum at Omaha, has attracted the widest attention of archaeologists and ethnologists. The careful carving reveals some knowledge of sculptoring. Then, too, the features reveal a distinct type of human being, much resembling either the ancient Maya or Toltec faces as revealed in the ruins of lower Mexico, or even resembling somewhat the Egyptian faces as revealed in the tombs and recesses of the pyramids.

Many tiny busts of burnt clay or terra cotta, less than half the size of a man's fist, have been found in the caves by Dr. Stearns and Dr. Robert F. Gilder, field archaeologist of the University of Nebraska. Always there is present in these the gaping mouth which strongly suggests the faces of the rain gods of ancient Mexico. They resemble also the many terra cotta masks and idols constantly being plowed up in the fields surrounding Teotihuacan.

Do these clay busts and soapstone carvings represent types of the races that made them?

Ethnologists and archaeologists believe they do. It is noteworthy that all Chinese gods have the slanting eyes. All Egyptian busts and paintings reveal the characteristic huge aqueline nose and the ear guards in the headdress.



Sectional view of a "cannibal" dwelling

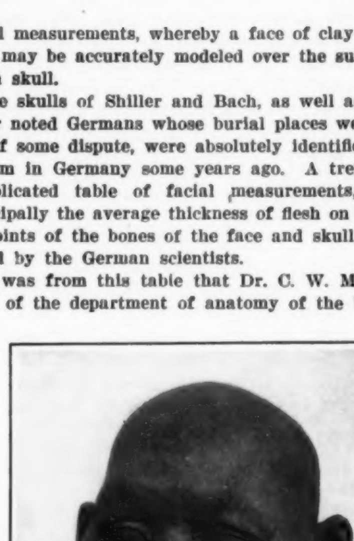
1. Accreted soil; 2. Roof material; 3. Floor; 4. Cache filling (mostly clay); 5. Fractured skull; 6. Wood ashes, bone and stone implements.

If the busts are characteristic of this Missouri valley race, then they were a race of strong masculine features with prominent, heavy facial bones, particularly the cheek bones and the angle of the jaw.

Exact reproduction of the faces of two individuals of this lost race have been made at the College of Medicine of the University of Nebraska. This has been done by means of a new German system of exact facial measurements, whereby a face of clay or plastilena may be accurately modeled over the surface of a given skull.

The skulls of Shiller and Bach, as well as those of other noted Germans whose burial places were a matter of some dispute, were absolutely identified by this system in Germany some years ago. A tremendously complicated table of facial measurements, covering principally the average thickness of flesh on thousands of points of the bones of the face and skull, was prepared by the German scientists.

It was from this table that Dr. C. W. M. Poynter, head of the department of anatomy of the University



Reproduction of an American pre-historic cave-dweller of the Missouri Valley

of Nebraska, and his assistant, Miss Myra Warner, worked on the skulls furnished them by Field Archaeologist Robert F. Gilder. The accompanying photographs show the faces they have thus built over the skulls of these cave-dwellers of the Missouri valley empire of centuries ago.

Strange as it may seem, this race of people mingled with their smattering of art and science the revolting custom of cannibalism.

Some six feet beneath the surface of the ground today is found what was once the cave floor. It is packed hard with the tramping of many feet, and is charred in many places from numerous camp fires.

A spot of decomposed ash is always found near the center of the floor, showing where the principal camp fire was kept. In some of the caves Mr. Gilder has found a smooth stone anvil near this fire. It is dished somewhat where stone hammers have worked long upon it. Near this crude anvil, in some instances, have been found crude stone hammers, smooth with much use.

Then around this anvil and hammer are often found fragments of human bone that show clearly they have been charred in the fire and mashed with the stone hammer.

The conclusion is that here about this central slab of stone sat sinewy warriors, hammer in hand, mashing bones and sucking human marrow, while in darker corners naked mothers cruned weird songs and suckled savage babies.

Looking at the dim history of the Toltecs of Mexico and Central America from the seventh century to 1064 we find that the terrible droughts and famines of the eleventh century gave rise to the practice of such human sacrifices.

It is at this point in the march of centuries that the curtain of oblivion is drawn over the Toltecs and Mayas. History at this point merely records that they fled from the famine and living fury of the fierce Aztec warriors just then charging over the horizon of history.

They fled, we know, to Central America, to Yucatan and to other parts unknown.

Because the sculpturing and clay-modeling of this lost empire of the Missouri valley is much like that of ancient Central America and Yucatan, scientists today are beginning to link the races together more and more. It is possible, they believe, that a branch

of these Toltecs and Mayas, fleeing from famine and the Aztecs, followed the streams northward for better pasture and more bison until they finally established this crude underground empire in the Missouri valley.

When Dr. Sterns of the Peabody Museum of Harvard and Dr. Gilder of the University of Nebraska make their final reports, more will be known about this strange people.

Were it not for one peculiarity of these caves, practically all relics of value in the research work would have been destroyed by the ravages of time. This peculiarity was in the construction of the cave. In one corner of each is found a cache, some four feet deep, bottle-shiped, with the neck securely plugged up with burnt clay. The inside of the bottle-shaped cache was well charred by fire, so that the cavity is to this day dry and free from the ravage of decay. It is in these places that most of the pottery, human bones, works of art, sculpture, beads, combs, and bone implements are found.

Theories and Problems Relating to Musical Sands*

By Cecil Carus-Wilson, F.R.S.E., F.G.S.

I HAVE given you a brief history of this subject, referred to the work and theories of other investigators, and explained the technical difference between noise and music. I will now endeavor to support my views by a few experiments. I have demonstrated the difference between noise and music in a simple way with these two book covers. One is impressed with irregular markings, and when I draw my finger-nail across its surface noise is produced. The other is impressed with a series of equidistant ridges, or corrugations, and when I treat it in a similar way we get music—in the technical sense—because the vibrations created are regular. Here is a beach sand, composed of quartz and other grains which are more or less angular, rough, and vary considerably in size. When I strike it in this cup with a plunger we get *noise* only. Here is another sand, composed chiefly of quarz grains, which are more or less rounded, well polished, and vary but little in size. When I strike it in the same way we get *music*. In the first case the vibrations set up are irregular; in the second case regular. Now, as to the origin of these regular vibrations, Professor Bolton, as I have told you, believed they were due to the vibrating of the individual grains when all the necessary conditions were present. I have told you why I am unable to support this view. Is there any other source of sound hidden away in the grains? If I strike this cup it vibrates and emits a musical note. But the note ceases directly I bring my hand in contact with the cup. This would also be the case with a bell—even the small sand-grain bells if they were in contact under the pressure exerted by striking the sand with a plunger. Can we produce any other kind of musical note from the deadened cup? I have here a fine steel point. The extreme end has an area approximately equal to that which a small grain of sand would have at its point of contact with the cup. I move the steel point vertically over the surface of the deadened cup, and get a squeak. This sound is quite independent of the resonance of the cup. The effect is improved when I use this piece of glass in place of the cup. When I draw the point vertically over the surface friction puts a drag on it, and tends to stop its progress. But the point meets the increasing frictional obstruction by finally jumping over it, so that it progresses by a series of "running jumps," and these give rise to the regular vibrations which produce the musical note. If I increase the number of steel points I increase the volume of sound. Hence, the greater the number of sand grains complying with the necessary conditions the greater the number of vibrations of equal length, and the louder is the musical note. The other side of this piece of glass is rough, and the steel point will not produce a squeak on this, and a sand composed entirely of rough grains is unmusical. This is the basis of my theory. I found that the quality and intensity of the notes emitted by musical sands depended largely upon the shape and composition of the vessels in which they were struck. I have referred to this in *Nature*. This porcelain cup gives good results, but when the same sample of sand is similarly treated in this flower-pot, this cardboard box, or this rubber vessel, it is practically mute. Pour it back into the porcelain cup, and it is as musical as ever! I believe that these interesting results are due to the fact that, in experimenting with small quantities of sand, their efforts to produce music need encouragement. This they receive, as you will have gathered from the article in *Nature* just read to you, when the grains move against the sides of a glazed porcelain or smooth wooden vessel. They possess greater freedom of movement in such vessels. In the case of the flower-pot, the box and the rubber receptacle, these encouraging factors are absent. Compression, too, produces compaction, and, therefore, loss of coherency in the sand. As the flower-pot is smaller at the bottom than at the top, the sand is compressed when struck. Coherency is also destroyed by wetting. This Eigg sand is quite musical when dry, but mute

Pink soapstone head, carved by an unknown race, found in a cave near Omaha

when I wet it. This wooden vessel produces good results, while in this one it positively screams. In the latter case, I believe partial compression causes the grains to rub with greater force against the sides of the vessel when the plunger is used, and because the smaller grains at the bottom are brought into action. The smaller grains accumulate at the bottom of the vessel during plunging tests, and these give a note of higher pitch. I have referred to this in *Nature*. Now a few words in regard to the plungers. Some are good for the purpose required, and others bad. I call them positive and negative plungers. This beech-wood ninepin, this deal paint-brush handle, and this glass pestle, as you see, are positive, while these

Burnt clay terracotta bust, found in a cave near Omaha, suggestive of the rain gods of early Mexico and Central America

of rubber and cork are negative, and this celluloid cylinder particularly so. Some negative plungers will give feeble results with fresh sand in larger quantities, and on a patch of musical sand *in situ*. A positive plunger may be rendered negative by covering the striking end with rubber. A negative plunger may sometimes be rendered positive by what I call "coaxing." Thus, you see, this negative cork will become positive if I screw this porcelain knob into one end. A cork may also produce positive results if fixed in the end of a glass tube or a piece of iron piping. This celluloid cylinder is a negative plunger, but if I place a positive plunger inside, it becomes instantly positive. Observe, however, that a wooden core does not improve the sound produced by the positive metal cylinder. This piece of hollow bamboo is positive. Here is a composite plunger; it is constructed of brass, cork, wood, tin and glue. It gives positive results with either end. I have shown elsewhere that the pitch of the note produced by any plunger is determined by the area of its striking surface. The striking surface of this one is nearly an inch in diameter; when I strike the sand in this cup we get a note of low pitch. Here is a smaller plunger with a striking surface about half an inch in diameter, and with this we get a note of much higher pitch. With a rolling pin and a large basin of musical sand, I can produce a deep note like the bark of a large dog, and with a lead pencil a note like a shrill whistle. But the pitch of the note may be varied at will by increasing or decreasing the bulk of the plunger. When I fix this brass knob onto the upper end of this plunger the pitch is considerably lowered. Indeed, it would be possible to play a tune on this sand. I think that the positive plungers vibrate in sympathy with the vibrations produced by the sand grains, and, acting as resonators and intensifiers, are responsible for the greater part of the sound we hear. Hence the pitch of the note does not depend only upon the area of the striking surface, but, rather, upon the size, or bulk, of the plunger—other things being equal. I think I can confirm my view. Here is a plunger which, if vibrating, would always have a constant note. At one end I have cut a large surface, and at the other a small one, but whichever end is used for striking the sand, the pitch of the note is the same. Another curious fact is that if I take these two positive plungers, giving a high and low note respectively, and strike the sand with both simultaneously, no note is produced. This is probably due to interference setting up general confusion in the vibrations, and so destroying the usual effect. This appears to confirm my view that it is the plungers, rather than the receptacles, which act as resonators.

*Abstract of a lecture delivered before the Geological Physics Society. From the *English Mechanic*.

Researches Upon Antiseptics

AT a meeting of the Académie des Sciences, Professor Richet set forth his researches on the subject of antiseptics. By the application of an original method, he attempts to establish a classification of antiseptic substances upon a new basis. His researches bear upon the effect produced by various chemical products upon fermentation, and by a study of the variations in the coefficient of fermentation he arrives at some interesting conclusions. As a whole, he finds that antiseptics can be divided into two general classes, those having a regular effect which can be judged in advanced and a second and irregular class. In the latter case the effect is variable in the case of different compounds and cannot be determined in advance. This is especially true for salts of silver and mercury. Taking the ensemble of his researches, they form an interesting attempt to substitute a series of rules and scientific laws for the empiric methods that have been largely in used in the choice of antiseptics.

Imbibition Exhibited by Some Shellac Derivatives

THE solid which separates on cooling a solution of shellac in boiling sodium carbonate, when immersed in cold water, expands rapidly and ultimately disintegrates to a flocculent precipitate. If immersed in water and allowed to expand to a point short of disintegration, subsequent immersion in strong sodium carbonate solution cause contraction; on being replaced in water expansion again occurs, and so alternate expansion and contraction can be obtained. Measurements were made of the expansion in water and in solutions of salts (sodium chloride and sulphate, ammonium acetate, and potassium chloride) of different concentrations, of this compound and of that obtained by dissolving shellac in borax solution and solidifying by cooling, and it was found that expansion is inversely proportional to the concentration of the solution. The soluble portion of the compound fully expanded in water is precipitated by strong but not by dilute salt solutions, thus differing from colloids. The differences between the behavior of the compound and that of substances such as gelatin and gum tragacanth are largely explained by this insolubility of the soluble portion in strong salt solutions. On allowing gum tragacanth to expand in a medium containing a constituent in which it is insoluble, *e. g.*, the alcohol in a medium of alcohol and water, similar behavior was observed, the expansion being inversely proportional to the concentration of the alcohol. Since the shellac compound is permeable to salt molecules, the mechanism of the expansion seems to be accounted for by the passage of the salt molecule through the diaphragm, the soluble nucleus dissolving in the presence of the salt solution, and the amount that can dissolve controlling the consequent osmotic pressure.—Note in *Jour. Soc. Chem. Ind.* on a paper by A. P. LAURIE and C. RANKEN in *Roy. Soc. Proc.*

Gasoline's Part in the Great War*

Failure for a Day Would Cause Serious Results

By Albert Lidgett, Editor of "The Petroleum Review"

If there be the slightest doubt in the minds of the motorist at home as to the immensely important part which is played in this war of nations by motor spirit and its allied refined products of petroleum, then a visit to the battlefields of France and Flanders will quickly dispel it. When the statement was made in the House of Commons the other week that adequate supplies of motor spirit were quite as essential as men and munitions if victory was to be on the side of the Allies, the case was by no means overstated. Rather, on the contrary, for should there be a dearth of supply of motor spirit even for a single day, then that vast organization across the Channel would immediately lose its balance, and our great fighting units would automatically become useless. This is the outstanding conviction which must remain indelibly stamped upon the minds of those who pay more than a cursory attention to the ramifications of war as waged today.

The motorist at home has borne the restrictions in regard to motor spirit consumption with a fortitude which has been and still is highly commendable. At the first he raised no voice of protest when for purposes of revenue his motor spirit was taxed, nor did he grumble when his supplies were cut down, while today—now that he is debarred the use of motor spirit for other than absolutely essential purposes—he looks upon the arrangement of conservation as one prompted by the exigencies of the situation. And he is not mistaken, for if ever there was a time when there should be true conservation of motor spirit supplies at home in order to render the greatest quantities possibly available for war needs, it is the present.

Let us, then, examine the question, and see exactly what is the position of motor spirit in connection with our war organization. In this respect we must recollect that our aerial fleets depend absolutely for their activities upon motor spirit. Experiments have been tried with substitutes almost without number, both as liquid and in the shape of gas, yet one and all have fallen far short of the requirements. The situation is met only by the provision of almost unlimited quantities of the finest high grade spirit, without which obviously we should have no effective air service available, either for the defensive at home or the offensive on the fields of battle.

On the sea, too, motor spirit plays an increasingly important part each passing week, for whether it be our units burning oil fuel or those utilizing the lighter products of petroleum as their motive power (and each class is steadily expanding numerically), there is the ever-prevailing need for large and still larger supplies.

But it is in regard to the use of motor spirit for road vehicles that we see the greatest demands existing through all the zones of war today. Our railway experts have performed a great work at the fronts, for some hundreds of miles of ordinary railway track have been expeditiously laid for the purpose of facilitating transport, while again miles upon miles of light railways take up the transport from the ordinary tracks and carry it nearer the centers of activity. But it is here that the locomotive, whether heavy or light, finishes its work, and the internal combustion engine assumes absolute control of the situation.

The magnitude of our motor spirit consuming organization at the various fronts is on a scale not easily appreciated. There is not one necessary article which has to reach our fighting lines but which has during at least a portion of its journey after reaching France to be conveyed by motor traction. The daily requirements of the legions of men, as well as the whole of the munitions of war, depend absolutely upon road transport, which, in its turn, must have to depend of necessity upon motor spirit.

Even the aftermath of battle has its particular calls upon motor spirit, for the thousands of Red Cross vehicles which have to transport rapidly the more seriously wounded to the centers of medical attention must all materially draw upon the supplies, while finally the operations of the salvage men also necessitate the use of large numbers of motor-driven vehicles. Whole fleets of motor vehicles are always in readiness at the rail heads, for it is upon them that confidence is placed for the material—whether in the shape of shells or foodstuffs—reaching its ultimate destination.

It was the privilege of the writer to visit the British front in France and Flanders during a recent tour by automobile from general headquarters. The scenes encountered en route to the different sectors all emphasized how absolutely dependent is the whole course of operations upon motor spirit. The main roads are nothing but tracks for the continuous use of the motor vehicle.

Large quantities of supplies of every description go to the war zones from the port of entry exclusively by motor, and on the roads—no matter which road one takes—not hundreds but thousands of these heavy lorries make up a continual procession on their way to the front—a procession broken only occasionally by the movement of divisions of troops and Red Cross vehicles, either going to or returning from that long line of khaki.

At various points of the roads—where the French railways cross the thoroughfares—a slight halt in the traffic causes the collection of a long stream of motor vehicles, the like of which is unknown in this country, while as one nears the actual zone of operations the road congestion is remarkable.

As one reflects that it is motor spirit and its adequate supply that renders such necessary road movement possible, the realization forces itself upon one that whatever so-called injustices are inflicted at home upon the ordinary motor spirit consumer, they are more than justified by the events at stake in the war zones.

Yet behind this great organization for the consumption of motor spirit at the fronts, there has necessarily to be a none the less carefully thought out organization to insure the supply of the essential petroleum products up-country after it has once reached France.

The writer had the special privilege of inspecting, in accordance with military arrangements, the system which prevails across the Channel for insuring the proper distribution of petroleum supplies for the military operations in general, and it is safe to say that this is one of the most complicated questions which has confronted our military authorities; the latter had need to introduce and perfect a system for the distribution of petroleum products, which, while insuring an adequate supply of the whole of the essential varieties of products, takes within its scope all possible precautions against waste. In times past one has frequently heard stories as to the wasteful way in which motor spirit, for instance, was utilized in the army zone, and it has been asserted that occasions are by no means infrequent when the cars themselves are washed with the product; in fact, everyone has heard assertions relating in one way or another to the unnecessary use of petrol regardless of the purposes served.

It may be that the same reasoning holds good in France as in this country: that occasionally men will be found who knowingly allow wilful waste. But if such instances occur, they are particularly rare, and the punishment meted out to the offenders is such as fits the crime. The writer can give his assurance that the prevailing system as practiced throughout our army zones is one which does not allow the unnecessary waste of petroleum products. The checking of indents for supply against the distance traversed and other means is a safeguard against waste, except in the cases of those unpatriotic men to whose nature both honesty and principle are foreign.

This much can be said, the general arrangement governing the division of motor spirit supplies is one approaching that of perfection. It is one of the most important branches of organization, and its management leaves nothing to be desired.

Having said thus much of the use of motor spirit in the war zones, let us, for an instant, take note of the organization which renders the supply of the petroleum products possible to the various units of military service when once the bulk stocks have arrived in France.

In a certain quarter of —— the central petroleum depot of the British armies is situated. It is well placed, for not only do the main lines of railway intersect it, but it has a considerable water frontage. Its bulk supplies, however, are drawn from another port, at which latter spot the usual bulk deliveries are made. These come from England, in spite of the assurance to the contrary made in the House of Commons some time ago, and this fact is mentioned lest readers, seeing the quantities now imported into the United Kingdom, may wonder why the present close restrictions as to consumption are in vogue.

The central petroleum supplies depot has at the moment no parallel either in this country or any other. It is not only a bulk receiving station, but it is the center for organizing the distribution all over the British war zones. Several acres are occupied by that necessary departmental work inseparable from a receiving and a consigning station. British Tommies form but a very small part of the personnel. Chinese labor is there in abundance, while in the various sheds devoted to the examination of the old cans as they come from the fronts, the repair of them and their syringing, and the subsequent refilling, female French labor predominates.

In order to form an adequate idea of the great volume of work which passes through this depot, it may be mentioned that, at the time of the writer's visit, the stocks of petrol tins—empty yet prepared for filling—were far in excess of three million. And the perfect organization prevents the slightest waste. The empty tins drawn from the front after use are all tested for leakage; they are "blown" for damage they may have sustained in transit, new faucets are soldered where necessary, and leakage holes repaired; then away they travel on a moving roller-way to the filling shops, where, after receiving their automatically measured two gallons of spirit, they pass to a position where female inspectors watch for leakages.

Then they are boxed in parcels of four—that is, eight gallons—and in such wooden crates are laden upon special trains in sealed closed wagons for transport up-country. Motor spirit for aeroplane work is naturally of special quality and specially colored tins are used, and, while this is transported from the railheads to the various aerodromes in motor vehicles, the heavier spirit is also conveyed to other inland centers for distribution to the various motor transport units. Whole trains depart daily from the central depot for up-country laden with this essential necessity of modern warfare.

But motor spirit is only one branch of the supplies dealt with at this gigantic central petroleum supply depot. The internal combustion engine would cease to be a useful unit unless it also secured effective lubrication, and so, while the organization at —— deals with the motor spirit itself, it also of necessity has its departments which exclusively handle lubricating oils of every description. These are parcelled from bulk stocks and sent up-country in either five-gallon tins or larger drums.

The lubricants dealt with range from the lightest oil to the heaviest axle grease, and all are dealt with by the same energetic hand which appears to rule the whole installation. In one department you may see coolies soldering receptacles which have long since seen their best day, in another are the French girls manipulating the tin plates from the Bliss machines for the making of the ordinary two-gallon cans (and thousands of new cans are being made each day), while in yet another portion of the installation are jocular Chinese loading up the oils into trucks for the Front.

What a business it is! Then there is the illuminating oil section—for illuminating oil is another necessity at the Front. The transport is usually effected in the five-gallon cases so familiar in the Far Eastern oil trade. It is this oil which eventually finds its way into those lonely dug-outs at the front, into the oil-heating stoves which play quite a healthy part when meal time approaches, or it may be the oil finds its way into that dim lamp which hangs in every Red Cross vehicle that carries its burden of injured humanity from the rear of the fighting trenches to the base hospital.

But half of the story of the part which petroleum products play in this terrible war cannot be written: it can only be left to the imagination. To oil is consigned one of the most important roles it is possible to play in this international struggle for freedom, and

*From the *Autocar*.

the pity of it is that we must be dependent upon foreign sources for our supplies, necessitating long ocean transport in circumstances of grave anxiety.

Whatever national use may be made of motor spirit at home, this use cannot be anything like as important as that which would be achieved in the battle zones of France and Flanders. The British Government has gone far in restricting its unnecessary use at home, but it is of vital necessity that the stocks of the product for war purposes should be kept as large as possible; today they are not great, in spite of the enormous drawings which are daily necessary, and, though this is not the time to talk of coming shortage, now is the moment to make the declaration that a most grave responsibility rests upon each one in this country who consumes one drop of motor spirit for purposes other than those of essentially national importance.

Sources of Potash*

By T. E. Thorpe

As is well known, the world's supply of potash during the last three years has been greatly curtailed owing to the present isolation of Germany, and compounds of potassium have, consequently, greatly increased in price. This, of course, has acted adversely on the interests of agriculture, of medicine, and of numberless processes in the arts which are more or less dependent upon the use of potash compounds. Up to within comparatively recent times such potash as the world needed was obtained from sea water, either directly, or indirectly through the medium of sea plants (*kelp* or *varec*); by the incineration of land plants (wood ashes); from *vinasse*, or the residue left on distilling fermented beet root molasses; from *suint*, or the "yolk" of sheep's wool, etc. These still continue to be sources of potash, but they are of comparatively subordinate importance when compared with the relatively enormous output of the Stassfurt deposits. All these sources, including those of the Stassfurt beds, are ultimately dependent on the primitive rocks of the earth—that is, to the decomposition of such minerals as potash felspar, potash mica, and the vast number of zeolites and other silicates which make up much of the rock-forming material.

Felspars are, in fact, the most abundant minerals in the earth's crust, constituting, according to Dr. Hatch, about 48 per cent. of the whole, the potash felspars forming the predominant proportion. Orthoclase, when pure, should contain 16.9 per cent. of potash (K_2O), but such a theoretical figure is never reached, owing to a greater or less admixture of soda. About 12 per cent. of potash is the usual amount, which is rather more than the average percentage in the Stassfurt deposits. Many suggestions have been made from time to time to extract the potash from the two chief varieties of potash-felspar, *viz.*, orthoclase and microcline, and from the intrusive igneous rock known as pegmatite, which is a mixture of quartz and felspar; and a large number of patented processes for this purpose are on record. It is said that upwards of one hundred patents on this subject have been taken out in the United States alone. One of the most promising of these was that of E. Bassett, who, in 1913, patented in the United States and Canada a process based on the discovery that powdered potash-felspar, when fritted with common salt, was decomposed, with the formation of potassium chloride, which could be leached out from the sintered material, and obtained sufficiently pure for technical purposes by fractional crystallization.

This process was independently discovered, and has been carefully studied, by E. A. Ashcroft, who has brought it to the notice of the Institution of Mining and Metallurgy in a paper which has just been published (Bulletin No. 159, December 13, 1917). The reaction is a reversible one, and for its success in affording the maximum yield of potash certain conditions of fineness, temperature, duration of heating, and absence of air and moisture must be observed, which, however, would seem to be easily reached in practice. Large deposits of suitable material are to be met with in Great Britain, notably in Cornwall and in various parts of Scotland and Wales. Other localities occur in Ireland. Some of these are already worked for pottery purposes, but others, as in Sutherlandshire, on the extreme northwest coast of Scotland, are untouched and would be eminently suitable sources of supply, and capable of yielding some 20,000,000 tons of material without going below visible outcrops.

Considerations of space prevent any fuller analysis of Mr. Ashcroft's proposals, but we are inclined to concur in his general conclusion that from a purely commercial point of view the attempt to work these Scottish deposits seems fully justified as likely to prove remunerative, and we further agree with his contention that, given the raw material of the potash trade (the chloride), manures and all other potash products can be produced at least as favorably in this country as in Germany, and that an important section of German trade may thus be wrested from her, whilst our own urgent needs for munitions of war, for the soil, and for the chemical industries may be supplied.

The Stassfurt deposits occupy an extensive basin in the North German plain, in Prussian Saxony, close to the borders of Anhalt. The brine springs which they furnish have been known and intermittently worked since the early part of the thirteenth century, but they ceased to be remunerative, as sources of common salt, in the first years of the nineteenth century, and their working was abandoned. In 1839 the Prussian Mining Office commenced a systematic examination of these deposits, and put down a number of borings in different parts of the area, with the result that the potash formations were found to occur in practically only one locality, near the River Bode, not far from Magdeburg. During the last third of the preceding century a new industry sprang up and the villages of Stassfurt and Leopoldshall, from being wholly insignificant places, became the centers of a numerous population.

The conditions under which the Stassfurt deposits have been formed were the subject of elaborate inquiry by van't Hoff and his coadjutors so long as the eminent Dutch chemist lived. Although his interpretation cannot be said to be wholly satisfactory, the investigation greatly elucidated the mode in which the beds are supposed to occur, and rendered it very probable that similar deposits will be found in other parts of the world. Indeed, their existence has already been proved. In 1909 large deposits of sylvine, or potassium chloride, were discovered in Upper Alsace, in an area of about 200 square kilometers, near Mulhouse. Two strata were found, the upper 3 feet thick, the lower more than 16 feet thick at a depth of from 1,600 feet to 2,100 feet. This field, unlike that of North Germany, seems to be continuous, without faults, and is of more recent geological origin.[1]

The issue of *La Nature* for November 24 contains an interesting account of what has been allowed to transpire concerning these Alsatian beds, from which the following particulars are taken. The deposits, although continuous, are far from being horizontal or uniform. On the contrary, they are folded and irregular. The lower layer of sylvine is surrounded and covered throughout the whole of its extent by the upper layer, arranged somewhat in the form of an ellipse, in plan not unlike, indeed, a painter's palette. At the edges the saline layers gradually thin out and disappear. From their great depth they are naturally at a high temperature, not less than 48° C. From statements made in 1912 it was calculated that the upper layer of sylvine contained about 98,000,000 cubic meters, distributed over 84,000,000 square meters, whereas the lower layer amounted to 603,000,000 cubic meters, spread over an area of 172,000,000 square meters, equivalent in round numbers to 1,500,000,000 tons of potassium salts, or 300,000,000 tons of pure potash. The first borings were made at Wittelsheim (originally in 1904, in searching for coal), and some fourteen others have been made over different parts of the area. The salt began to be won in 1910, and in 1912, from the Amelia mine, with 200 men, the daily output reached 300 tons. The mineral, brought to bank, was crushed and powdered and either treated directly for the manufacture of "muriate" or exported.

The potash layers are composed of bands, alternately red and gray, consisting principally of a mixture of sylvine and rock-salt. The red bands, colored with ferric oxide, contain the principal amount of the potash salt, whereas the gray consist mainly of common salt. In addition there are found thin layers of argillaceous schist and anhydrite. The content of potassium chloride varies from 20 to 68 per cent., and rarely falls as low as 10 per cent. The raw products contain only insignificant quantities of magnesium salts and may, therefore, be used directly in agriculture after grinding. In this respect they are more advantageous than the Stassfurt salts, which need separation from the large quantities of associated magnesium salts. The Reichweiler factory is capable of treating daily about 260 tons of the raw mineral, producing from 40 to 50 tons of pure potassium chloride. The content of bromine is so small as not to be worth extraction.

The production of Alsatian potash is carefully regulated by the German Government, and by the law of May 25, 1910, the Amelia mine, the only one actually at work in Alsace, was allowed to produce no more than 1.46 per cent. of the total yield of the Empire, *i. e.*, 9,000 tons of pure potash, or 45,000 tons of raw salt, corresponding with an extraction of fifteen wagons per diem, far below what it was capable of affording. At the beginning of the war, in spite of some improvement in the situation, the fifteen Alsatian mines, capable of yielding in the aggregate about 800,000 tons per annum, were allowed to sell only 80,000 tons, and the total amount reserved to Alsace was permitted to be only about one-tenth of the German production. This action is, of course, due to the attempts of the German authorities to control and strengthen the monopoly they practically possess—a condition which would be altogether modified by the return of Alsace to France, and by the rôle which the State mines of Strassfurt might be made to play in the case of a war indemnity by Germany.

Of the other considerable natural deposits which are known to occur, the most important are those of Spain and Abyssinia. The Spanish beds occur at Suria, in Catalonia, and today belong to the Solvay Company. They have been found at depths of from 40 meters to 60 meters, but certainly extend much deeper. They date probably from the end of the Eocene or the beginning of the Oligocene period and are widely distributed, the potash salts occurring irregularly mixed with rock-salt. The potash compounds consist of carnallite and sylvine in layers of an intense red color, with alternate reddish layers of common salt. The richest zones appear to follow anticlinal folds running from south to north to Cardona, Suria, and Callus. The area explored is only some 230,000 square meters, but it is said to contain about two and a half million tons of carnallite and nearly a million and a quarter tons of sylvine in local thicknesses of 17 meters of carnallite and 3.75 meters of sylvine. At present these Spanish deposits are not utilized, owing to the influence of Germany on Spanish affairs. The Cortes was offered a bill in order to promote the working of the mines, but it was opposed by a faction in the interests of Germany, and no result followed. A royal decree in June, 1915, modified the conditions, but these were still so restrictive that the Solvay Company was prevented from exploiting the mines. On the other hand, certain Spanish corporations, working in concert with the German syndicate at Stassfurt, have obtained concessions in the vicinity of Cardona, and State reservations have been created in the provinces of Barcelona and Lerida; but no further action has been taken, ostensibly on the ground that the Spanish Geological Institute has not yet completed its explorations.

The Abyssinian deposits belong to Italy. They occur in Erythrea, at 90 kilometers from the coast to the southeast of Massaoua, and at 10 kilometers to the north of Atel Bad in longitude 40°, close to the Italian frontier. Their exploitation has hitherto been very difficult, owing to the hostility of the Abyssinians. These conditions are now notably improved, partly by a more effective possession by the Italians, and partly by recent changes in the Government of Abyssinia, which is more favorably disposed towards the Allies. The deposits already furnish about 20,000 tons per annum. Not much is known concerning their physical characteristics or the conditions of their formation, but they are certainly much more recent than those of Alsace and Spain, which are Tertiary; they have probably been formed by the comparatively recent evaporation of an ancient arm of the sea running north and south, due to one of the great lines of rupture extending from Palestine and traversing the whole of the east of Africa along a region still of volcanic activity.

Conditions such as probably have produced the Stassfurt deposits are still at work and may be observed in several parts of the world operating over large areas, as, for example, in the Adji-Darja Bay, in the east of the Caspian Sea—a bay 2,000 to 3,000 square miles in extent, and almost entirely shut off from the Caspian by a bar. There is here a continuous separation of salt, estimated by Schleiden to be about 400,000 tons per diem, with an outflow of dense mother-liquor back to the Caspian, except where it sinks in the deeper parts of the bay, when the mother-liquor salts are gradually deposited. None of these areas has been investigated with such care as that of the North German plain, but the general conditions which have led to their production are seen to be similar, although local circumstances, especially the extent to which they were subjected to an intermittent influx of sea water, have modified the nature, relative amounts and distribution of their various saline constituents.

*From *Nature*.

[1] Cf. Prof. Lunge in Thorpe's "Dictionary of Applied Chemistry."

Photos by The Gilliams Service

Two gallons of blood are taken from this horse each month for making serum

Testing and weighing serum before it is sent abroad

Making Anti-Toxins for War Use

At the Laboratories of the University of Toronto

Very recently His Excellency, the Duke of Devonshire, publicly opened, in Toronto, Canada, a most notable addition to the University of Toronto, in the shape of magnificently equipped new laboratories, which according to medical men of authority the world over will place Canada in the forefront of the scientific world as regards the most up-to-date and perfect equipment for the proper preparation of life saving anti-toxins for the use of the men in the trenches as well as the civilian population at home.

Previous to May, 1914, no preventive or curative serums with the exception of typhoid and smallpox vaccines were prepared in Canada. In that month, as if in anticipation of the great war, so quickly to follow, the University of Toronto planned to open a laboratory for the production of diptheria and tetanus anti-toxin, anti-meningitis serum and anti-rabies (Pasteur) vaccine, as well as smallpox, with a view to free distribution in Canada.

The outbreak of war increased the difficulties of getting the costly equipment and expert help required and added to this the world's supply of tetanus anti-toxin ran short, owing to the large quantities required on the western front where frequent lockjaw infection in the early days of the conflict made this serum a necessity.

In 1915 the Canadian Red Cross received from the medical director of the Canadian forces over seas an urgent request for 10,000 doses of tetanus (lockjaw) anti-toxin for immediate shipment to France. When efforts to buy them in the United States were made, prices were found to be prohibitive and the Toronto University at once stepped in to aid. Colonel A. E. Gooderham, who in addition to being a member of the Red Cross executive is a governor of the university, offered to equip a special laboratory for the purpose of producing this most valuable anti-toxin. In addition, the department of militia and defence offered to make a grant of $5,000, on condition that the entire output should be available for the army, if needed. The university accepted this offer and promised to supply the anti-toxin at the lowest possible cost.

The laboratory was opened immediately, under Dr. R. D. Defries, a highly skilled man in this line of scientific work, and has since been preparing and sending to France at a cost much lower than any obtainable in the United States, all the tetanus anti-toxin required for the Canadian overseas forces as well as the second British Army Corps, considerably over 50,000 packages have been dispatched up to date.

Upon realization that the laboratory equipment was inadequate for the tremendous amount of research work the war demanded and that accommodation was needed for horses and other animals used in making anti-toxin. Colonel Gooderham purchased a 50-acre farm, 12 miles north of Toronto, where an additional laboratory and stables have been built. These are known as "The Connaught Laboratories of the University of Toronto," the late governor-general having taken a keen interest in this work.

Dr. J. G. Fitzgerald of the university department of hygiene, who is now in charge of these laboratories, says with regard to them: "Canada now has in this institution one most favorably camparable if not superior in the scope of its activities, to the serum department of the Pasteur Institute at Paris; the Lister Institute, London, and the Research Laboratories of the Health Department of New York City."

In addition to the many hundreds of lives saved overseas by the products of this laboratory there has been, since its inception, a marked drop in the death rate of Toronto from infectious diseases, especially diphtheria. Thanks to the products of the laboratory, anti-toxin for diphtheria, which used to cost in Canada from $3 to $4 per dose, is now obtainable from the laboratory for the poorest patients free of cost. Also for many other diseases, which come under the scope of research work in these laboratories, anti-toxin or serum, may be obtained absolutely free of cost, so that in future no Canadian unable to afford payment for such relief need die for the lack as hitherto has happened.

Filtering the serum

The first process in the making of the life-saving tetanus anti-toxin in the Toronto laboratory is the cultivation by incubation in the proper medium, usually beef tea, of the tetanus germs. They are carefully introduced into a culture flask which is stopped by a tampon of cotton. These flasks containing the bacilli are then placed in an incubator maintained at a temperature of something over 100 degrees Fahrenheit where they are left for some time. After a proper period for the germs to fully ripen and develop, the tubes are removed from the incubator, the virility of their contents tested and then, if correct, a serum is prepared from this material with which the horses are inoculated with gradually increased doses, administrative at stated periods, until their blood has attained a proper immunization against tetanus germs when it is safe to draw from them the anti-toxin which immunizes the person on whom it is used against the attacks of these same toxins.

The amount and quality of anti-toxin produced by the horses varies greatly according to the animals. Some horses proving much more valuable in this particular than others. They have one horse, named Dick, at the Toronto laboratories who is certainly doing his bit in war work, as two gallons of excellent anti-toxin is drawn from him every month without affecting his health in any particular. Nor is the process of drawing the serum from the horses painful to the animals as is evidenced by the patient manner in which they stand while it is being done.

When the anti-toxin has been taken from the horses it is conveyed to the laboratory where it goes through various interesting preparative processes before it is ready for human use. First, it is carefully filtered to remove any possibility of foreign or irritating matter having crept in. Then it is tested as to strength, in this respect it varies at times, and weighed to determine if it is the correct specific gravity. Passing these tests satisfactorily it is portioned into correct doses and then put into sterilized glass capsules which, after being properly sealed, are carefully packed in air and water-tight cases ready for shipment to the front in France where the anti-toxin is issued to the various medical units who use it as the occasion requires which is very frequently.

The preparation of the vaccine for rabies, at the Toronto laboratory, is in many particulars a delicate undertaking.

A rabbit is inoculated with the germs of hydrophobia after it has fully developed the disease at a certain state, its spinal marrow, in which the germs of rabies seem to find congenial soil and congregate in vast numbers, is removed. The proper removal of this marrow requires great skill. It is also not without danger as if the operator should by any chance have a slight cut or tiny break in the skin of his hands, which should come in contact with the diseased marrow, he is almost certain to develop the dread disease.

The marrow removed, it is carefully placed in sterilized bottles which are then stoppered with cotton and gauze. In these bottles the marrow is allowed to remain for some time until it is quite dry, after which it is powdered and then used, when needed, for making microbe cultures from which the rabies anti-toxin is finally produced.

Photos by The Gilliams Service

Removing the spinal cord from a rabbit to be used in making a remedy for hydrophobia

Each of these bottles contains two spinal cords from which a remedy for hydrophobia is prepared

The Hardening of Steel by Chromium and Copper*

By L. Grenet

THE minimum rate of cooling required to render the influence of quenching efficacious varies to an enormous extent, according to the quality of the steels concerned. The rate of cooling necessary to secure the hardening of special steels is lower than that necessary to secure the hardening of ordinary carbon steels. The penetrative influence of heat treatment is, therefore, more efficacious in the case of special steels than in carbon steels, and this, as is well known, constitutes one of the chief characteristics of the special steels. The difference between the influence of the heat treatment at the surface and in the center of steel pieces, which is very considerable in the case of carbon steels but small in steels in which the hardening effect has penetrated deeply, justifies the stipulation which, for some time past, has been introduced into specifications to the effect that after hardening, but before the removal of the pieces for testing, the ends of certain pieces, such as gun parts, should be cropped. As a further consequence of the ease with which the special steels can be tempered, it is possible to harden certain of them by mild quenching operations such as oil and air tempering, which occasion little deformation or cracking. The copper steels have already been investigated, notably by Brustlein in France and by Stead in England. The present author has devoted himself more especially to ascertaining the influence of copper on the depth of the hardening effect, particularly in the presence of chromium. His experiments have been made on crucible steels from Firminy.

1. When, apparently, the percentage of nickel is below 5 per cent., steels containing above 4 per cent. of copper forge badly. Confining the observations to forgeable steels, it has been observed that copper, by itself, while slightly increasing the depth of penetration of the hardening effect, does not increase it sufficiently to confer on steels the property of air tempering, even when small parts, such as 10-mm. square bars, are concerned.

It is to be remarked that if the amount of nickel that could be introduced into the steel were limited to 4 per cent. the same conclusions would be reached.

2. In the presence of chromium the copper increases, fairly noticeably, the depth of the penetration of the hardening effect to the extent of rendering the employment of chromium-copper steels a matter of practical interest.

It has only been upon steels containing both chromium and copper that the more extended experiments, of which an account is about to be given, have been made.

3. None of the chromium-copper steels prepared by the author possess the property of undergoing transformation (the γ to α transformation) at low temperatures, nor, therefore, that of hardening when the cooling is exceedingly slow, whereas chromium-nickel steels rather high in nickel (4 per cent. of nickel and 1.5 per cent. of chromium) possess this property.

The addition of 4 per cent. of copper to a steel (No. 10) containing 2.52 per cent. of nickel and 1.59 per cent. of chromium does not likewise communicate to it the property of hardening on very slow cooling during annealing.

4. The addition of nickel to steels containing chromium and copper allows of the depth of the penetrative influence of quenching being increased, but only to the detriment of the property of softening by annealing. Having due regard to the size of the pieces and the use to which they are to be put, there is an advantage to be derived from the introduction of a more or less high proportion of nickel into steel.

5. The simultaneous addition of copper, nickel and chromium to a steel permits of the easy preparation of steels which possess a tendency to deep penetration of the hardening effect sufficiently marked to render the air-hardening of large enough pieces (for example, gearings) efficacious, without such steels losing the property of becoming softened by the orthodox annealing processes employed in the case of ordinary carbon steel.

These two properties, (*a*) depth of penetration of hardening effect, and (*b*) facility for softening on annealing, can be obtained amongst steels the composition of which may vary within fairly wide limits.

6. According to the tests carried out by the author the chromium-copper and chromium-nickel-copper steels possess, after hardening and tempering, practically the same mechanical properties (tensile and impact) as chromium-nickel steels having approximately the same carbon percentage and the same penetrative capacity for hardening. It should, however, be pointed out that the chromium-copper steels assume, on quenching at somewhat low temperatures, a rather coarser grain on fracture than that exhibited by nickel-chromium steels; there is therefore more danger of their becoming burned.

Summary.—Copper increases the depth of the hardening effect in steels.

The influence of copper in the presence of chromium is marked. One per cent. of copper suffices to confer on steels containing 1.5 per cent. of chromium an interesting degree of capacity for sustaining the hardening effect in point of depth. The action of the copper is more limited than that of nickel. All the chromium-copper steels prepared by the author, containing less than 3 per cent. of nickel, soften on annealing at high temperatures, and consequently do not harden on quenching when the rate of cooling is very slow.

The simultaneous employment of copper, nickel and chromium allows of semi-hard steels being prepared which can be hardened by air-cooling on largish pieces and yet softened by the ordinary annealing methods used for carbon steels. The limits of chemical composition within which such steels should fall are wide enough to render their manufacture easy.

The chief influence of copper, like that, indeed, of other special elements, is to increase the depth of the penetrative influence of the quenching, and consequently the efficacy of heat treatment in the interior of the pieces subjected thereto. Apart from this influence on the depth of penetrative influence of quenching the author has failed to detect any other useful effect of copper on the properties of steel.

NOTE ON THE HARDENING OF STEELS CONTAINING HIGH PERCENTAGES OF CHROMIUM

The special steels most commonly employed generally contain more nickel than chromium, because the somewhat violent action of chromium, which is liable to lead to cracks while quenching, is dreaded. The author conceives it useful to recall a few statements he made on a former occasion in this connection.†

The rate of cooling required to lower the transformation temperature in the neighborhood of ordinary temperatures, that is to say, in order to produce hardening, varies within enormous limits. It is very difficut to ensure uniform cooling during quenching, even when all the factors acting on the rate of cooling are rigorously defined. It is similarly very difficult, when metals which require a rapid rate of cooling are treated, to ensure a uniform degree of hardening. If, on the contrary, metals which undergo energetic hardening on air-cooling are employed, it is obvious that when they are cooled in a liquid in which the cooling effect is more rapid the hardening will still be energetic and uniform, if the conditions of the cooling vary.

Steels containing at least 1.4 per cent. of chromium and a little copper or nickel are, in these circumstances, of a kind that can be quenched in a liquid between the temperature of 120 deg. and 350 deg. (real colza oil does well) without the energy of the cooling varying much, and in these circumstances there is not much fear of cracks developing.

Generally speaking, pieces of medium thickness (30 mm. or less) are susceptible of being so treated if made from air-hardening steels. Such metals soften very well on ordinary annealing, and after annealing are easy to machine. Naturally if it be desired that the hardening effect should penetrate to the core in very thick pieces, or if air-hardening is to be adopted, metals should be employed which have a greater susceptibility to the penetrative effect of hardening.

*From a paper read before the Iron and Steel Institute, in London. Reported in *Engineering*.

†"Hardening in Heated Liquids," *Bulletin de la Société de l'Industrie Minérale*, July, 1913.

Medicine and the Military Death Rate

DR. WOODS HUTCHINSON, in a Chadwick Lecture recently delivered at the Robert Barnes Hall, Wimpole Street, gave some remarkable figures relating to the influence of medicine upon the military death rate. By wiping out epidemics the doctor, he said, had actually kept the death-rate among the civil populations of the Allied countries as low as, and in some cases lower than, it was before the war. By redoubling the care and protection of young children almost as many additional young lives had been saved as adult ones had been on the field of battle; so that the populations of the Allied countries were practically holding their own. His control over wounded infections was so masterly, that of the wounded who survived six hours 90 per cent recovered, of those who reached the field hospitals 95 per cent recovered, and of those who arrived at the base hospitals 98 per cent got well. Anaesthetics and antiseptics had not only enormously diminished pain and agony, but had made amputations rarer and grave cripplings fewer than ever before in war history. Barely 5 per cent of the wounded were crippled or permanently disabled. From the statistics made public there was good reason to believe that the death rate of this war, in spite of the colossal increase in instruments and engines of scientific slaughter, did not much exceed 5 per cent per annum.—*Jour. Royal Soc. Arts.*

The Causes of Disease—I*

An Attempt at Classification with a View to Prevention

By Ernest S. Reynolds, M.D. Lond., F.R.C.P.

I have chosen for this lecture the old but none the less important subject, the Causes of Disease. I shall probably have nothing new to say, but in the exploration of the many new forests into which modern medicine has led us, with its many new names and many new methods, it is well to avoid not being able to see wood for trees. If causes were more carefully considered there would not be the discreditable evidence so often given by members of our profession in the Law Courts, especially in cases under the Workmen's Compensation Act. If causes were more carefully weighed we should not have the ultra-specialist assigning the majority of diseases to causes peculiar to his specialty, the neurologist treating a sciatica really due to an impacted uterine fibroid tumor, the gynæcologist or the nasal surgeon performing operations on neurotic patients the seat of whose troubles is really in the brain; nor the abdominal surgeon operating for gallstones when the patient is suffering from periodic bilious vomiting due to migraine; nor hear of successive operations on another patient on the colon, appendix, duodenum and gall-bladder to cure pains due to the gastric crises of tabes dorsalis; nor advising the removal of a supposed gastric cancer because the patient was suffering from the wasting of Graves's disease—all instances which have recently come to my own notice.

My thoughts have been specially directed to this subject of causation by trying to discover the cause of that very distressing and prevalent affection, disseminated sclerosis, of which more anon, and also by reading a recent small volume by our colleague, Dr. Mercier, entitled "Causation and Belief," a book, if I may say so, of excellent merit, and, of course, of much clarity and infinite wit, and which, I think, should be read by every medical man.

DEFINITION OF DISEASE

We must first have some definitions. I have been surprised to find no definition of disease which seems satisfactory. It is obviously the converse of health, which is defined by Professor Adami as a state customary to a series of individuals in which they perform their functions easily and unconsciously. But much more than this is necessary to constitute health. A man with much increased blood pressure, another with compensated mitral disease, and a third with glycosuria may all perform their functions easily and unconsciously, but they are not healthy and would be rightly refused for life assurance. The changed anatomy and function of organ and tissue are of paramount importance as well as the man's feelings and present abilities. But in this connection we are at once confronted with two difficulties. First, there is no such thing as a standard man, as no two people even of the same race or same family are exactly alike; but we can without difficulty imagine an average man who is a mean between others varying but little in structure and function. The second difficulty is that of advancing years, for after reaching a state of maturity a man's tissues and functions change and decline. Now, I should be sorry to include these changes as disease, to imagine that all of us over 50 years of age are in a state of disease. These changes are natural processes, like the falling of the leaves in autumn, and may be defined as those changes found on an average at any particular age in a particular race; it is partly on these normal average changes that tables of expectation of life are constructed. Abnormal changes due to age are, of course, those that occur years before they occur in the average man—the early whitening of the hair, early degeneration of blood-vessels, early changes in nerve, tissue, and so on.

These two difficulties set aside, I think we may safely define *Disease* as that condition of an individual in which there is, apart from normal age changes, a harmful change of the structures or functions or sensations usually found in the average man of any particular race. This definition will include neurasthenia and hysteria amongst diseases, but will not, of course, include malingering.

DEFINITION OF CAUSE

As regards Cause, the best definitions I know are those of Dr. Mercier, whose views I will put as shortly as possible. He first defines *Effect* as a change connected with a preceding action, or an unchange connected with an accompanying action (such as the unchanging steady movement of an engine) on the thing changed or unchanged. A *Result* is the changed state of a thing on which the effect has been produced. Endocarditis of the mitral valve is the effect of the action of germs on the valve; mitral stenosis is the result. A *Cause* is the action or cessation of action connected with a sequent change or accompanying unchange in the thing acted on. He then makes a strong point about the difference between cause and *Condition*. The latter is a passive state of or about the thing acted on by a cause and material to the effect. It may be a favoring condition where more of an effect will be produced by a cause if the favoring condition is present; or a necessary condition where an extra effect or an earlier effect is produced when the necessary condition is present.

Dr. Mercier points out that age, sex, race, time of year and climate are frequently put down as causes of disease. But these are not actions but are passive states and are therefore not causes. The age of 60 years, the female sex, the negro race, the winter, the climate of Uganda are not causes of disease, but they are conditions in which certain actions especially or only occur and are therefore favoring or necessary to the effect produced. Strictly speaking, this is correct and in the close investigation of causes must be fully allowed for. But in a wider sense condition may be for convenience included in all the necessary circumstances precedent to an effect produced and in this sense Dr. Mercier himself recognizes the term in his chapter on the causes of death.

METHODS OF ASCERTAINING CAUSES

We must now consider shortly the methods of ascertaining causes. The five canons of inductive logic put forward by John Stuart Mill, Dr. Mercier clearly shows not only to be unsatisfactory but often useless and often absurd and in their place he gives 12 methods which are worth quoting:

1. Instant sequence of the effect on the action.
2. Subsumption of the case in hand under a general law.
3. Assimilation of the case in hand to a known case of causation.
4. Association of the action with the effect when other material action can be excluded.
5. Association when the association is of proved constancy.
6. Association when, though inconstant, the association is more frequent than casual concurrence will account for.
7. Association when, though itself inconstant, the associated effect has constant peculiarities.
8. Concurrent and proportional variation of the action and the effect.
9. Common rarity of the action and the effect.
10. Correspondence of a quality in the effect with a quality in the agent.
11. Coincidence in space of an action or a condition with the effect.
12. Coincidence in time of the action with the effect.

Instances of these methods are of course given by Dr. Mercier, but all of us can quite easily find instances in medicine, and can see the value of the methods in ascertaining the causes of disease. In many diseases in which the exact cause is not known, such as measles, Hodgkin's disease or tetany, we may make shrewd guesses by the use of these methods. But in other diseases, such as true tic-douloureux, spleno-medullary leukæmia or sclerodermia, we have not sufficient knowledge of antecedents and no similarities with other conditions, so that at present no cause can even be guessed at.

Of the many fallacies found in trying to ascertain cause, one of the commonest is the *post hoc propter hoc* argument. This may be and often is perfectly true in the sense that a cause precedes an effect. But to be true a connection must be shown to be established by one of the methods of causation "between the action that is *ante* and the effect which is *post*." But it cannot be too strongly asserted that mere sequence does not establish causation. A man strains himself while lifting a weight; he continues his work, perhaps, with some difficulty; two days afterwards he commences with pneumonia and dies, and a claim for compensation is put forward, and it is often most difficult to persuade a lawyer that there is no necessary connection between the original slight injury and the death. A man cleans out drains from a dye-works and gets chrome eczema and chrome holes on the hands. He happens to vomit the same day that he cleared the drains; he continues to have dyspeptic symptoms and occasional vomiting and loses flesh, and a few months after dies from a gastric cancer, and without being able to show the slightest connection (except mere sequence) between the injury to the hands and the gastric cancer a claim is made for the death. But it is common knowledge that legal compensation actions abound with such cases; and there is no doubt that the supposed efficacy of many drugs is falsely based on the *post hoc propter hoc* argument, the real healer being nature.

COINCIDENCE

Another fallacy, which is of such enormous importance that I think it worth while to dwell on, is that of pure coincidence. It depends, of course, principally on the fact "long ago pointed out by Bacon that there is in the human mind a peculiar tendency to dwell on affirmative and to overlook negative instances" (Fowler's "Inductive Logic"). To my mind this is the explanation of most of the curiosities of telepathy, thought reading, "dreams coming true," and of psychic research, and not unfrequently is the explanation of things being falsely ascribed as causes of disease. The number of coincidences in life is actually enormous, but relatively is only a very minute fraction of the myriads of thoughts, dreams and sensations which continuously crowd our daily life awake and asleep. Think of the innumerable incidents which fall on the eye and the ear in a walk through the city; to the great majority of these we pay no heed, but immediately one incident fits in with another a coincidence is established; we fix on this and remember it and very often call it, instead of a pure coincidence, an act of causation. Let me give some examples of pure coincidence.

On the morning of February 14, 1876, Elisha Gray registered his patent for a telephone at the Washington Patent Office; on the afternoon of the same day Graham Bell, quite independently in every way, registered his patent for a telephone in the same office. A few years ago a friend of mine was reading Canon Core's book "Lux Mundi"; in order to keep the back clean she picked up from a table near by the discarded paper cover of another book and put it on the one she was reading; shortly after it was found that the paper cover's title was "The Light that Failed" by Kipling. A few weeks ago I casually opened a periodical lying on a hotel table and fronting me was a colored print of Constable's Haywain; a few minutes afterwards I opened a box of cigarettes and in it found a print of the same picture.

In professional life coincidences are common; we all have "runs" of particular cases, or cases from particular districts or from particular doctors.

Four years ago I remember three cases of myasthenia gravis at one time in the Manchester Royal Infirmary, two of them being under my own care. About the same time I saw three cases of Bence-Jones's albumosuria within a few months. Recently I saw two cases of unrelated Thomsen's disease in one week, and the next week a case with all the usual signs of Thomsen's disease which had apparently come on after shell shock, but in whom I found no family history. A few weeks ago late one night I wrote a medico-legal report on a case of death from pulmonary embolism occurring in a man whose left tibia had been fractured by a falling stone while he was at work; the first case I saw the next morning was an officer with a pulmonary embolism from a fractured right tibia due to gunshot.

COINCIDENCE OR CAUSAL CONNECTION?

In these cases of pure coincidence I am told by a mathematical friend that there is no formula which applies to them. Percentage is no test. Suppose the same 1,000 persons to start at different times of each day from the East-end of London, walking at different speeds, and another 1,000 to start from the West-end; the number of times each year that John Smith (coming from the East) will meet Thomas Brown (coming from the West) at St. Paul's may be quite

*Bradshaw lecture delivered before the Royal College of Physicians of London, and republished from *The Lancet*.

considerable, and if no causal connection can be shown will be pure coincidences. But William coming from the East may meet Mary coming from the West at St. Paul's only on two occasions, although each one passes that spot each day, but if the two meetings were pre-arranged by themselves or their friends the meeting is an act of causation. Similarly in disease; we sometimes find epileptics who have mitral stenosis, but these are two very common affections and are certain to meet as pure coincidences in the same individual fairly frequently. Trench fever is common, so are lice on the bodies of soldiers; and in the same way it must not be necessarily assumed that lice are the sole carriers or in any way the carriers of trench fever, although they may be one method of conveyance. I have seen a very great number of cases of disseminated sclerosis since the commencement of the influenza epidemic in 1889, but one must not assume that influenza is of necessity a cause of disseminated sclerosis.

Let us take now low percentages. Late nervous affections of the tabetic or general paralytic type are said to occur in about 7 per cent. of all persons who have had syphilis. Yet no one doubts the causal connection for two reasons: first, that the observations are being constantly corroborated; and, secondly, that it conforms to the methods of ascertaining causes. In the epidemic of arsenical beer poisoning in the Manchester district in 1890 I had about 1,200 cases of arsenic poisoning under my care; amongst them I had 16 cases of herpes, only 1.3 per cent. Was this a pure coincidence or was there a causal connection? The latter certainly, for as a matter of fact, knowing that others had found herpes in arsenical poisoning, it was the presence of herpes which made me look for the arsenic. Actual pain and fine tremors are very rarely indeed found in lead-poisoning. Personally I have only seen these symptoms in two or three cases; but I have no doubt that there is a causal connection, because others have seen them, though rarely; and, knowing that lead will cause motor paralysis, it is not unreasonable to suppose that it may rarely cause pain and tremor. Perforating ulcer of the foot I have only seen, I think, twice in diabetes mellitus, but I have no doubt it is secondary to the neuritis and changes in the sensory roots of the spinal cord found in that disease. Some years ago I published in *Brain* an account of four families, in two or more members of which disseminated sclerosis occurred. Since then I have had no fresh instances of familial incidence in this disease, and, although the disease is common, hardly any other observer has noted it as a possible family affection; therefore I am inclined to believe my cases were more or less coincidences. I also published a note in the *British Medical Journal* of instances in which I had seen disseminated sclerosis and Graves's disease in the same person; here, again, no corroboration being forthcoming, I think I was dealing with pure coincidence.

DISEASES AND PRIMARY CAUSES

A glance through any text-book of medicine will reveal an enormous number of diseases with particular "names." This is as it should be; for without such large numbers of names we could not carry on our personal observation of diseases nor could we communicate our thoughts to others. For old as it is I do not think that Hobbes's definition can be too often repeated, that "a name is a word taken at pleasure to serve for a mark, which may raise in our mind a thought like some that we had before and which being pronounced to others may be to them a sign of what thought the speaker had or had not before in his mind." (And I should like, in an aside, to say that I consider it an unwarrantable crime for old names to be altered or used in different circumstances without very full justification. "Cursed be he that removeth his neighbor's landmark.") A further study of all these diseases will show, however, that the things that cause them can be narrowed down to a comparatively few classes, so that from a purely prevention point of view the number of actual diseases, considered as primary and not as regards their final effects, is similarly few. For instance, most diseases of the heart are not primary, but are the final results of some infective process; the same thing applies to most glandular affections; liver diseases are often circulatory or due to some poison; very many brain affections are due to circulatory troubles, and diseases of vessels to premature old age, and so on with any other system, the skin, the kidneys, the lungs, or the spinal cord. One has only to think of the numerous diseases set up by three primary causes—alcohol, tubercle and syphilis—to realize the truth of this.

As an example of remoteness of cause and effect the following may be given:

A few weeks ago I was asked to see a lady who had recently been operated on successfully for an hour-glass stomach. But she insisted that she could not walk and remained bedridden. I was told this was due to hysteria, presumably post-operative. A short examination showed that she was a marked example of combined postero-lateral sclerosis which had been slowly coming on for two years, and was a remote effect of an original gastric ulcer with subsequent alimentary disturbances and anæmia.

A HEALTHY COMMUNITY: PROBABLE DISEASES

Let us suppose 1,000 healthy men and 1,000 healthy women, each aged 20 years, free to marry, with no hereditary taint, put to live in a perfectly healthy island with sufficient flora and fauna to maintain life, and not under a fantastic communistic government, and let us try to imagine from what diseases they will suffer and from what they will die.

Theoretically we may suppose that one of these people will have any disease, and that they will all die aged 100 years owing to the natural processes of age. But as practical physicians, not treating human beings as pure pieces of machinery, we know that no two human beings are exactly alike either in structure, functions, habits, or feelings, and this being so every person responds differently to his surroundings, and therefore some of the inhabitants of our island will suffer from various affections and the ages at death will vary considerably. It will facilitate my suppositions if we agree to include in our study not only the original 2,000 inhabitants, but also the next two or three generations, without, of course, any admixture from the rest of the world.

INJURIES

Injuries will inevitably occur. Of purely so-called surgical injuries, varying from burns to fractured skulls, I need not further speak. We must also include injuries due to childbirth, those to the mother and those to the child, the latter partly asphyxial but principally resulting in the many types of birth palsy, and not infrequently in some types of epilepsy and perhaps of mental deficiency. Epilepsy in adults, osteo-arthritis, and probably new growths, are often mere end results of previous injuries or irritations. Cold and heat applied externally may, of course, cause injuries, whether they result in frostbite or in burns, and it is not unreasonable to call them injuries when they produce other effects. Heat will cause heat syncope, and the sun will cause that form of sunstroke called by Sir Patrick Manson "sun traumatism." I particularly wish to dwell for a moment on the effect of cold. We are all, I think, prepared to admit that "getting cold" produces a condition of lowered vitality which allows certain germs to act and effects occur, and in our broad use of the word *cause* cold would be a cause of these diseases. But apart from germs, will cold or chill cause disease? Personally, I think it may. Take the case of a man who has been "wet through" and had to remain in his wet clothes until he felt chilled. I am prepared to believe, until fresh evidence is forthcoming, that he may as an effect have a parenchymatous nephritis, in a pure case of which I know no evidence which connects it with a germ growth. Again, I am a firm believer in the bad effects of "draught." The breezes of a mountain top may harm no one, but sitting in the draught from an open window is, to my mind, a pernicious habit. It not only may for the time lower resistance, but can undoubtedly, quite apart from germs, so far as evidence goes, cause facial paralysis and brachial neuritis. I have seen paralysis of muscles supplied by the external popliteal nerve so caused, and in one case a paralysis of the muscles supplied by the fifth cervical root, and I think it likely that many cases of sciatic neuritis are due to cold pure and simple.

FOOD—POISONING

Food being of prime necessity, I will consider it next. Results of improper feeding will sooner or later appear on our island. Practically each person will differ from every other in the quantity and quality of the food he takes. Some will naturally require more food than others; some will have healthy or unhealthy likes or dislikes for certain foods; others will have food idiosyncracies; others, according to inclination or opportunity will take too much food, others too little, and so will arise obesity (the commencement of many diseased conditions) of emaciation. Probably many abnormalities of blood pressure are due to improper feeding. Some will bolt their food, causing dyspepsia in various forms. Some may get diarrhœa, others constipation, with its many undesirable effects; but few physicians will, I think, be prepared to accept the formidable and curious catalogue of the effects of intestinal stasis as tabulated by Sir Arbuthnot Lane. From improper proportion of foodstuffs some may develop scurvy and others (in infancy) rickets.

Cases of poisoning will certainly occur on our island, gaseous, liquid or solid from animal, vegetable, and mineral sources, and we must include poisoning from putrid foods. We may concede that tobacco smoking is indulged in, and we may get various acute, and more important still, chronic effects from overindulgence, effects which are commoner than is usually supposed. Sooner or later alcohol will be distilled and taken, and at once we add enormously to the number of diseases produced, with possibly also effects on the offspring. Here may also be mentioned poisoning from intrinsic sources, such as presumably may be the cause of pernicious anæmia, rheumatoid arthritis, combined posterolateral sclerosis, possibly of disseminated sclerosis, and the numerous diseases reulting from altered secretions from glands, ductless and otherwise; some of these poisons may originate from germ growth, others from altered functions and altered metabolism, two classes to be considered later.

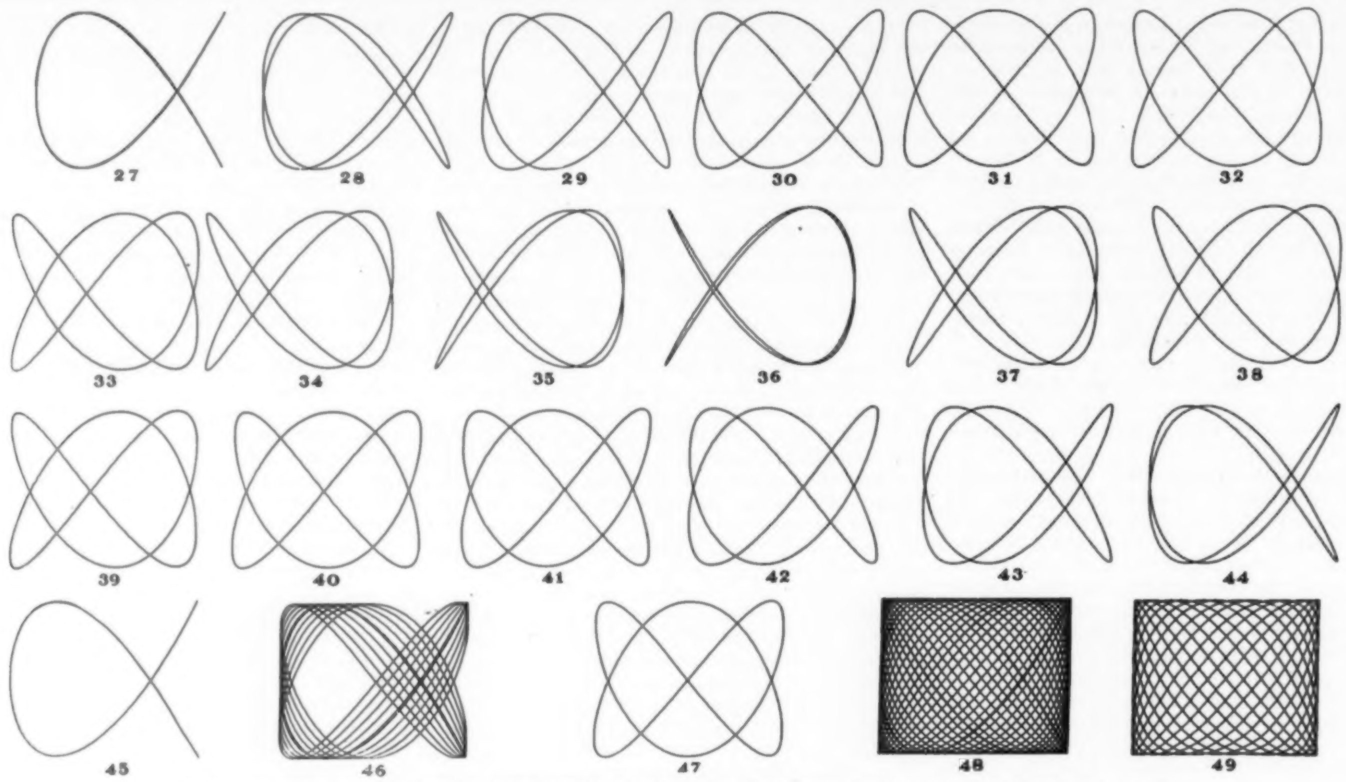
OCCUPATION—STRESS—METABOLIC VARIATION

Our islanders must, of course, work. If we suppose the work is agricultural, and if more or less evenly divided, no special diseases should arise therefrom. But sooner or later some will work less than others either from getting unduly rich or because of indolent habits. The former may become obese and indulgent, the latter will suffer the usual penalties of underfeeding and also perhaps of depleted homes and of overcrowding, with their usual results to themselves and their children. Sooner or later also other industries will arise which will again by degrees become more and more specialized, and we are at once introduced to the numerous diseases of occupation about which so much excellent work has been done in recent years.

With increased work there will develop (partly as a result of competition, partly of habit and partly of necessity), worry, hurry and stress, often much increased by the tyranny of the insistent telephone and the irritation of the rushing wheel. Stress especially affects the digestive, the circulatory, and the nervous systems. The affections set going by improper or insufficient food, by hurried and irregular meals, by hyperchlorhydria (often, I think, the result of worry and rush) and by constipation I have already touched upon. Functional affections of the heart, tachycardia, palpitation, and actual cardiac dilatation may result from stress. More important still, as leading to so many affections often in the end fatal, we get the increased blood-pressure which in industrial communities is so enormously common and tends to early unnatural senility. Equally common are nervous affections, hysteria, neurasthenia, psychasthenia, and insanity. I believe that acute congestion of the brain may occur causing prolonged unconsciousness or even delirium, and for my part I am inclined to think that Graves's disease is primarily a nervous affection and not primarily a disease of the thyroid gland. It is a difficult question to decide whether these acquired results of stress are handed down to appear as nervous symptoms in the offspring, for it may be that these results would only appear in certain members of our community who are of a more nervous temperament than the others, and that it is merely the temperament which is handed down. Perhaps some signs in the children may be the results of imitation from living in a household where rush and stress are always occurring. One type of stress, not, I think, sufficiently dwelt on, is that caused by nursing sick relatives through long illnesses, especially when the illness ends fatally. This, of course, occurs principally in women, and is one of the most potent causes of functional nervous disturbance that I know. It is one of the tragedies of life to see a woman gradually becoming more worn, more faded, and less likely to marry as the result of being tied hand and foot to another's sick-bed; and the worst of the tragedy is that very often it is inevitable and "none can succor her."

We have assumed that each of our inhabitants differs from the other, and therefore we may further assume that each will functionate and metabolize differently. For some unknown reasons these alterations in function and metabolism may lead to diseased conditions. Such as obesity, diabetes, mellitus and insipidus; gout, hyperchlorhydria, and some altered digestive processes, including constipation; altered functions of the ductless glands, and possibly the tendency for certain secretions and excretions to form calculi. Some altered blood conditions, such as chlorosis and polycythæmia rubra, belong to this group.

[TO BE CONTINUED]



Simple rectangular curves. Figs. 27-48 with ratio 2:3, showing effect of change of phase. Fig. 49 with ratio 11:16

A Compound Harmonic Motion Machine—II

Adapted for Drawing Any Predetermined Curve With Mathematical Accuracy

By William F. Rigge

Concluded from Scientific American Supplement No. 2197, Page 91, February 9, 1918

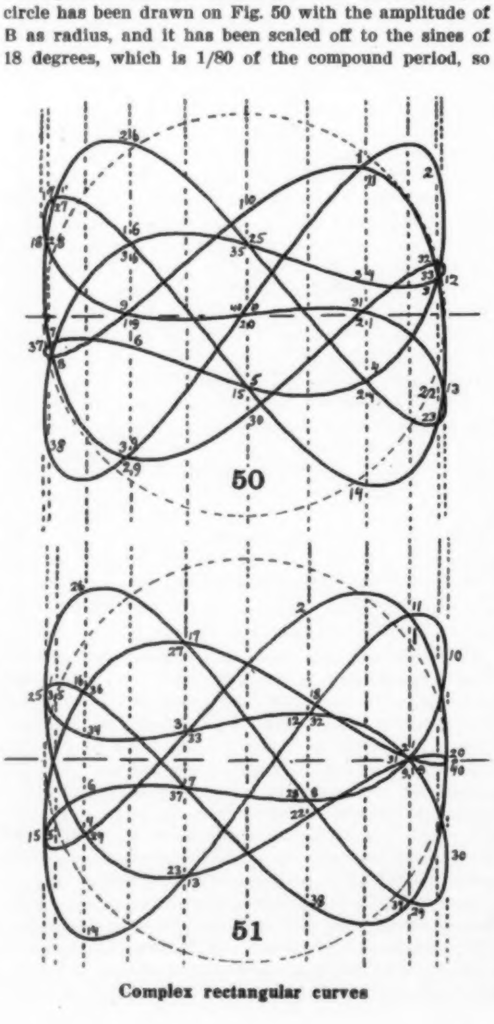
PHASE DIFFERENCES

Figs. 27—49 show the gradual changes that come over a curve with the ratio 2:3, when the phase difference is increased 10 degrees between the successive figures. Fig. 27 starts with both dials at 90 degrees. At No. 31 the phase difference is 40 degrees and at No. 32, 50 degrees. For a difference of 45 degrees we would have No 47, intermediate between 31 and 32, with both dials at one moment reading 0 degree. When the phase difference is very nearly 90 degrees, we have No. 36. If it had been 90 degrees exactly, 36 would be 27 reversed. The succeeding Nos. 36—45 are then the same as the preceding ones in reversed order or position. No. 47 is the middle curve, and 45 one of its extremes. No. 46 is a partial composite, embracing three variations between them. No. 48 is a complete composite of half the whole series 27—45, that is, of 27—36, since the second half, 36—45, if drawn, would lie perfectly on the first. No. 49 is one continuous curve with the ratio 11:16, which is within about 3 per cent. of 2:3.

COMPLEX CURVES

The curves 19—49 shown thus far result from only one component in each direction, that is, from two simple sine curves at right angles. Let us now add another component to one of them. Figs. 17 and 18, as we saw before, are the resultants of 15 and 16 having the ratio 8:5 and unequal amplitudes. Let us confine ourselves to Fig. 18, when the components are at 0 degree together at the start. For the ratio 8:5 for the pen, unit D had a 30-cog wheel and unit E a 48-cog wheel. Let us put a 60-cog wheel in B for the paper. We may then take our chances on the results and be surprised at its unexpected simplicity or complexity. We may forecast it, of course, with all mathematical vigor, if we choose, and draw the curve by points as we shall see presently. But this method will not appeal to most of us. It is advisable, however, to forecast the curve to some extent by examining the ratio, to see whether this is moderately simple or deterrently complex. The ratio, or rather the period, is the reciprocal of the number of the cogs on the gear wheels. For 30, 48, 60 cogs we must use 1/30, 1/48, 1/60. The least common denominator being 240, we have the numerators 8, 5, 4, which are then the numbers of the complete cycles of the components D, E, B in one resultant cycle. On Fig. 18, we divided the compound period into 40 parts. As 4 divides 40, we may use the same subdivision.

With dials D and E at 0 degree, as in Fig. 18, let us put B also at 0 degree. In one complete resultant cycle, the pen moves to the right and left 4 times. To represent this lateral simple harmonic motion, a circle has been drawn on Fig. 50 with the amplitude of B as radius, and it has been scaled off to the sines of 18 degrees, which is 1/80 of the compound period, so



Complex rectangular curves

that only the even ones are used in this Fig. 50, the odd ones being served for the following one. With Fig. 18 open before us, we begin with its O. Everything is then O on Fig. 50, and the point O is in its center. The ordinate of No. 1 in Fig. 18 we lay off on the second vertical line to the right of the center of Fig. 50, and find No. 1 marked there. We then go to No. 2 and find it readily. No. 3 is on the same vertical line with 2, because the pen has already begun to move to the left. Half way between 2 and 3, it was on the extreme right, because $2\frac{1}{2}\times2\times18$ degrees$=90$ degrees.

In this way the whole series of the 40 numbers of Fig. 18 may be identified on Fig. 50. Both figures, 18 and 50, are symmetrical with respect to the center. Both are central curves obeying the mathematical definition that every chord passing through this center is bisected there when it joins conjugate points, that is, points having equal ordinates with opposite signs and equal abscissal differences from the center.

Fig. 51 shows what Fig. 50 changes into when dial B is put at 90 degrees when D and E are at 0 degree. This curve 51 is symmetrical with respect to the horizontal line, because this bisects the chords joining conjugate points.

If Fig. 18 were drawn on gelatine or other transparent and flexible material, rolled into a cylinder in four turns, and held up to the sun with its axis at right angles to the rays, its shadow on paper, also at right angles to these rays, would be Figs. 50 and 51, according as points No. 0, 20 and 40 would be nearest the sun or turned 90 degrees to the right.

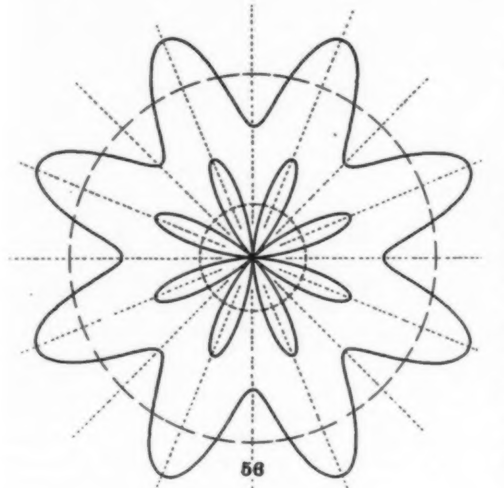
Figs. 52, 53, 54, 55 show the combination of unit D with 24 cogs, E with 48, and B also with 48. D and E are at 0 degree together at the start, and B is then successively at 0, 30, 45 and 90 degrees.

Two components on both the pen and the paper would complicate the curves too much to interest the reader. Three would be almost hopelessly intricate. So would changes of phase differences. The components being given, however, the machine would trace them without difficulty.

III. POLAR CURVES

The most interesting class of curves is that of the polar curves, in which the paper is given a rotary motion. For this purpose the paper carriage is removed and replaced by the disc shown in Fig. 2 and 4. This

receives its motion through a miter or bevel wheel from the axle of unit B, so that its speed may be made equal to or half of that of the gear wheel B, thus practically doubling the number of its cogs. The principle here is that the axis of abscissae, which in the preceding classes of curves is always a straight line, is now bent into a circle of any desirable radius and with any number of revolutions, whole or fractional or mixed, the ordinates being then measured from it in the direction of the radii. Thus if we take 8 cycles of a suitable simple sine curve, such as the whole of Fig. 15, and bend its axis into the large circle shown in Fig. 56, we will obtain the large 8-pointed star there drawn. We notice, of course, that because the points of a curve must be at unequal distances from the center of rotation, they will be more crowded together the nearer they are to it. The consequence is



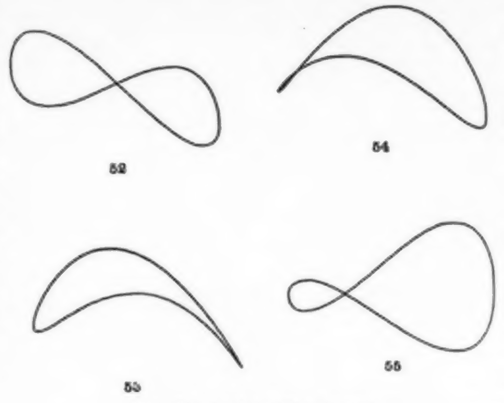
56

Simple polar curve. Ratio 8:1

that the smooth hummocky loops of a sine curve will become sharply pointed or suspitated, as the expression is, when they approach the center of the disc, and will be much extended when they are near its periphery. Thus if we contract the large circle in Fig. 56 until it becomes the smaller one, that is, in practice move the drawing pen so close to the center that the higher (or inner) points of the sine curve (the notches in the large star) actually approach the center, or, in other words, put the pen at the center when its dial reads 90 degrees, the larger star will change into the small one. When the circular axis is still further contracted, the higher points of the sine curve will be thrown beyond the center of rotation and form smaller lobes on the other side, until when the reference axis is reduced to a point and the lobes are all equal, the smaller 8-pointed star in Fig. 56 becomes the 16-pointed one in Fig. 57, in which latter case, however, the amplitude has been doubled in order to produce a larger figure. These four classes of curves are called respectively curtate, cuspitate, prolate and equifoliate. They are produced mechanically by merely shifting the pen so that it does not reach the center, just reaches it, or passes a shorter or equal distance beyond it.

In most machines of this sort, as the one by Prof. R. E. Moritz, of the University of Washington, in the Scientific American Supplement of August 5, 1916, and in the *American Mathematical Monthly* for May, 1917, the pen always travels in the line of the center of the disc, but in the present one it may move on any other line parallel to it. This property gives rise to curves far exceeding the others in beauty and in mathematical complexity, which last, of course, is no deterrent factor to the draughtsman. Thus if in Fig. 57 the pen is shifted the merest trifle out of the central line, we have Fig. 58. A greater shift gives Fig. 59, and a still greater one Fig. 60.

In these five curves 56—60 the ratio is 8:1, that is, the pen moves up and down 8 times while the disc makes only one revolution. This is the greatest ratio at present possible with the machine. Each ratio has its own peculiarities, but in general the greater it is, the sharper are the lobes of the figures, and the less it is the rounder they are. The reader may imagine that the ratio 1:8, in which the disc rotate 8 times in one cycle of the pen,



52 54 53 55

Complex rectangular curves

would be an uninteresting medley of expanding and contracting circles. We leave it to his taste to pick out the curve that pleases him most in those that are to follow.

SIMPLE RATIOS

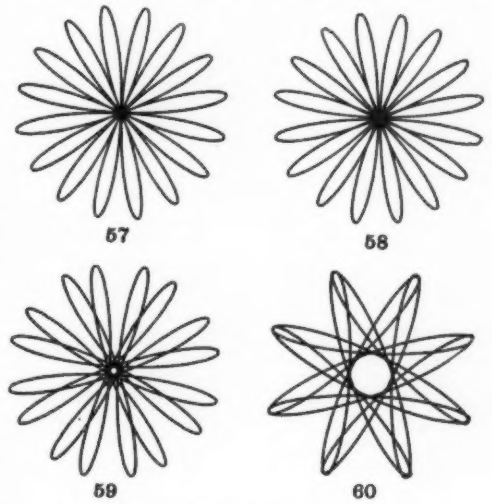
Figs. 61-64 show the ratio 1:1, the pen moving on the center line. The general equation is $\zeta = b - a \cos \theta$, in which b is the radius of the reference circle and a the amplitude, so that one cycle of a sine curve has its axis AE of Fig. 8 bent into a circle. Very often the equation is written with a plus sign between the two terms on the right side, that is $\zeta = b + a \cos \theta$. In this case the figures are turned half way round. In Fig. 61 b is greater than a, and the pen never reached the center of the disc. In 62 b=a, the pen just reaches the center. This curve is known as the cardioid. In 63 b is less than a, and the pen passes a short distance beyond the center. In 64 b=o, and the pen passes the same distance beyond the center that it falls short of it half a cycle later. The figure then becomes a true circle, and is traced twice. These four figures 61-64 thus show the four classes mentioned before.

If in this last figure, No. 64, we were gradually to change the phase of the disc or of the pen by taking the ratio 15:14, which is very close to 1:1 (as we did before in Figs. 22 and 23) Fig. 64 would change into 65, in which, however, the pen moved a trifle aside of the center. If in 65 we lifted the pen off the paper whenever it moved inward from the circumference toward the center, we would have No. 66. Two such figures like 66 when placed with their inked surfaces in contact and properly centered, would unite to form No. 65. In this species of curves, when the pen moves on the central line, the angle θ in the equation would have the coefficient 15/14. or a similar one dependent upon the ratio used.

Figs. 67-77 show 14 varieties of the ratio 28:5, illustrating all four classes of the curtate, cuspitate, prolate and equifoliate, with the pen moving on the central line or on others parallel to it. Fig. 78 is a spiral of Archimedes, which was drawn by winding up the pen chord at a uniform rate. It may be classed under our harmonic curves if we imagine the crank at 0 degree and the amplitude infinite, that is, so large that the pen moves with uniform speed on the central line.

COMPLEX RATIOS

The figures shown thus far, 56-78, employed only one component for the pen. When two are used, the curves become more complex. If we take the resultant of the two sine curves of Figs. 15 and 16 as shown in Fig. 17 when the two cranks are at 90 degrees together at the start, and bend its straight axis into the circle shown in Figs. 79, 81, 82 and 83, so that this axis makes respectively 2, 4, 5, 2½ revolutions, we will have the figures there drawn. The combination was such that the gear wheel in D had 30 cogs and E 49, while B had in turn 120, 60, 48 and 96. The first, Fig. 79, came as a distinct surprise on account of its simplicity, because a complicated curve had been expected. The reason was that the numbers of the cogs 60, 48, 120 were taken by inadvertence, whereas it is their reciprocals which should have been used, and these will be found to be in the ratio of 8:5:2. With the same setting of the pen the disc made respectively 2, 4, 5, 2½ revolutions in Figs. 79, 81, 82 and 83. All



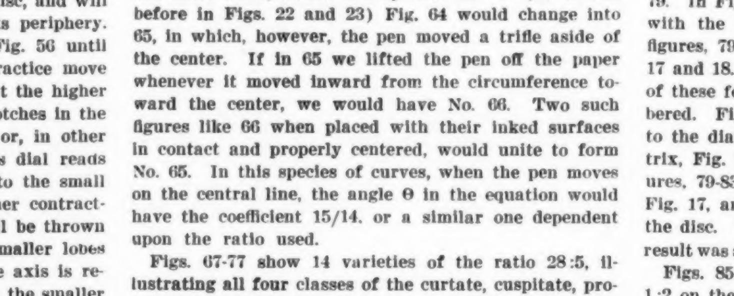
57 58 59 60

Simple polar curves. Ratio 8:1

the forty points of Fig. 17 are marked on these figures. In Fig. 84 the axis of abscissae dwindled down to a point, the speed of the disc being the same as in Fig. 79. In Fig 80, Fig. 18 was used as the generatrix, also with the same speed. The dotted radii in all these figures, 79-84, indicate fortieths of the period of Figs. 17 and 18. In Fig. 83 there are two symmetrical series of these forty points, only one of which has been numbered. Fig. 79 is seen to be symmetrical with respect to the diameter through 0, 20, 40, just like its generatrix, Fig. 17, whereas Fig. 80 is not. In all these figures, 79-83, the highest point of the curve, 0 or 40 in Fig. 17, and 26 in Fig. 18, just reached the center of the disc. When the lowest point was placed there, the result was an unsymmetrical curve somewhat like Fig. 80.

Figs. 85-96 show what may be done with the ratio 1:2 on the pen carriage, when the components start at 0 degree together or at 90 degrees, and the disc has the period of the slower component, or one twice as long. The latter case may always be recognized in the central curves. The first and second figures in the second row differ only in this particular. It would be an interesting and not an over-difficult problem for a mathematician knowing the few facts just stated, to find the amplitudes and initial phase differences of the original components.

Ever so many other curves with numberless varieties of simple and compound ratios have been drawn with the machine. But those shown sufficiently indicate the principle and its varied application.



61 62 65 63 64 66

Simple polar curves. 61-64 with ratio 1:1. 65-6 ratio 15:14

CHARACTERISTICS OF THE MACHINE

The geometrical principle of the up-and-down motion of a revolving crank pin, which is used in this machine, instead of a swinging pendulum, embodies so many advantages in addition to the educational factor of its simplicity that it is useful to call attention to them.

1. It presents very clearly to the student the three elements of simple harmonic motion: the period in the number of cogs on the gear wheel, the amplitude in the effective radius of the crank pin and the phase in the momentary angular position of the crank on the dial.

2. All these three elements are very easily changed, and their numerical values for any position of the pen readily found.

3. The ratios are variable within wide

limits, ranging at present from 8:1 to 1:4. The closest ratio is 16:15 and its reciprocal. The ratio is, however, never incommensurable, but could easily be made so for the polar curves by substituting a disc drive in place of the miter and bevel gear.

4. The pen may be made to move at any speed, it may be stopped at any point and its direction reversed by crossing the rubber drive belt. It may also be lifted off the paper and set down again at pleasure while the motor is running, and thus draw or redraw certain parts only of the figures.

5. The figures drawn are in principle mathematically correct. Not only may the three elements of the period, the amplitude and the phase differences at selected points of the curve be determined upon in advance, but we may feel secure that they cannot be altered by friction nor by any variation in the speed of the motor. The amplitude is continually decreasing in machines employing pendulums, and we have no assurance that the initial phase difference is still operative. Still more mathematical accuracy is lost when two pendulums, swinging at right angles, are connected by rods to the pen, because these rods are then really radii of circles which force the pen to move in arcs about the pendulums as centers. It is true, however, that these variations in the pendulum machines, together with their greater facility of obtaining incommensurable ratios, enable them to draw finer figures in certain cases. An excellent quadruplex pendulum machine of this kind was constructed by M. J. Hoferer, S. J., and described in the SCIENTIFIC AMERICAN of April 1, 1899. It has a very ingenious let-go mechanism for obtaining differences of phase.

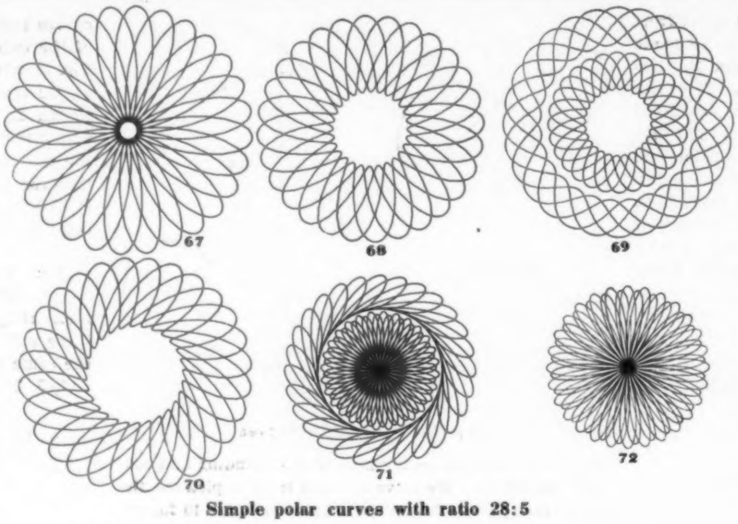
6. The revolving wheel machine as here designed not only draws all three classes of curves, sine, rectangular and polar, but is multiplex in principle, whereas the pendulum machine cannot be more than quadruplex.

7. The wheel machine will draw curves on any plane surface and with any pen or tool. It is not confined to a stylus and a blackened glass plate. India ink and paper may be used, and the original drawings presented to the engraver. The figures in this article have all been taken directly from the machine without the least retouching except the insertion of reference lines, which also might have actually been drawn on the machine before the paper was removed.

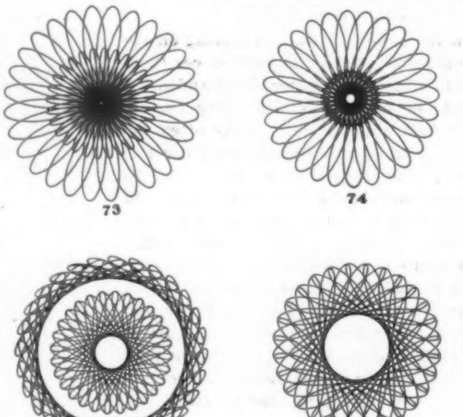
8. When a curve has been drawn, a second and third, and as many as one might desire may be placed on the same paper or on any part of it. This was actually done in the case of Fig. 48 and in many others.

9. The curves may be projected on a screen and their generation followed by audience. This may be done in all cases by reflected light and, except for the polar curves, also by transmitted light. For this last purpose the paper carriage has been made pretty large and its top of plate glass in order that its central part might offer no obstruction to the rays. The disc was not arranged to transmit light, because this would have introduced considerable complexity into its mounting.

10. The mechanical principle employed by the machine permits the addition of all mechanical contrivances for drawing curves. This, however, was not contemplated when it was first designed, and is not intimated in its name. The interested reader will not fail to see the possibilities of such additions. Should he project the construction of a similar machine, the writer's experience would warn him to employ only the best mechanical skill within his reach, to reduce friction everywhere as much as is possible, and to be prepared for many disappointments. Thus



Simple polar curves with ratio 28:5



Figs. 73-77 Simple polar curves with ratio 28:5.

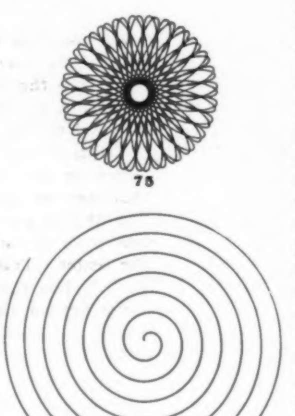
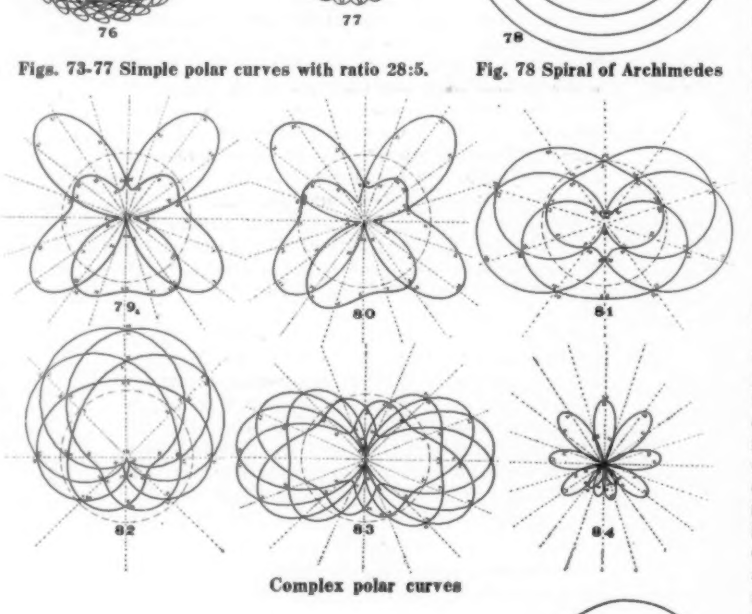
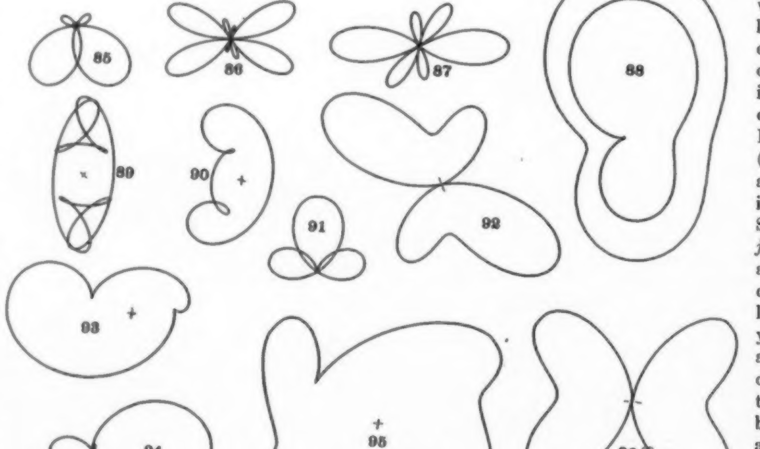


Fig. 78 Spiral of Archimedes



Complex polar curves



Complex polar curves

in the present machine the side elevation is the second that was tried, the movable rectangular frames in the units are the third of their kind, and the flywheel the fourth. The undesirable small vibrations or shiverings of the drawing pen are hard to trace to their sources and may be noticed in some of the figures here presented. But this mechanical and accidental imperfection is only of a temporary character and is a small item compared with the many advantages and capabilities of the machine.

Inducing Rain by Electricity

WHILE we on this side of the world are chiefly interested in the prevention of rainfall, in Australia the reverse holds good, and experiments are being carried out "down under" with an electrical plant for the purpose. The experiments carried out are said to be effective. According to a Sydney newspaper, careful research showed the inventor, Mr. Balsillie, that in fine weather there was a charge of positive electricity in the higher regions of the air, and that when it rained negative electricity predominated. He was studying the effects of mountains on rainfall, and came to the conclusion that hills acted as conductors of the negative electrical energy with which the earth's surface is charged. He argued that all that was necessary, therefore, to give flat plains the same advantage as regards rainfall as hilly country, was the free passage of the negative electricity to the higher regions of the air. His rainmaking plant now consists of a set of two or three kites, which are let up on galvanized flexible wire to an altitude of between 4,000 feet and 6,000 feet. The negative current is taken from the earth by means of a terminal, which is well grounded. Of course, the first essential in the business is wind. In his tests at Bookaloo and elsewhere, Mr. Balsillie has found that rain invariably falls after the kites have been in the air for from six to ten hours. In addition to the testing station on the Transcontinental Railway line, another station is being established in the Northern Territory for Government experimental work.—*The Engineer.*

Transmission of the Trematode in Venezuela

THE Trematode, *Schistosoma* (*Bilharzia*) *mansoni*, occurs frequently in man in Venezuela; adult specimens of this parasite were found by Dr. Risquez (1916) during post-mortem examinations in the School of Medicine at Caracas in 20 per cent of the cases. Drs. Iturbe and Gonzalez have recently published from the laboratory of the former, an account (8 pp., two plates) of experiments made with the view of finding the intermediate host of this parasite in the neighborhood of Caracas. The four common fresh-water "snails" of that area are two species of Planorbis, an Ampullaria, and a Physa, and the first three can be infected experimentally by adding to the water in which they are living the ciliated larvæ, or miracidia, of *S. mansoni*, but it is evident that *Planorbis guadelupensis* is the only species which naturally serves as the intermediate hose of *S. mansoni*. The development of the miracidium in this Planorbis, and the formation of rediæ (described as having a widely open mouth and a rudimentary gut) and cercariæ, are in accord with the account by Miyairi and Suzuki of the corresponding stages of *S. japonicum*. The cercariæ of *S. mansoni*, after escaping from the infected Planorbis, can live in water for at least twenty-four hours. Experiments on white rats and on young rabbits and dogs showed that they acquire the parasite by the entry of cercariæ by the mouth or through the skin, though the actual penetration of the skin by the cercariæ was not observed. Naturally infected *Planorbis guadelupensis* were found in six of the seven localities examined near Caracas, and of 400 specimens from one of the canals 120 proved to be infected. —*Nature.*

Restoration of Materials After Fires

Modern Methods of Salving

RESTORATION of cast iron, whether rough, in process or finished, is feasible in practically all cases, except when the metal has been distorted or cracked by heat, or by sudden and unequal cooling, the method of doing so varying according to size, intended use and finish. If the material is rough, on which no work has been expended, little or no damage can result, although it is possible for small articles to acquire a state of rust sufficient to add to the cost of the material at the time of damage. If the finish is to be plated, and even though a portion of the machine work has been performed, the damage may readily be less than if a machine or polished finish is intended, for the reason that the plating or finishing process would of itself remove evidence of rust. In other words, the same process and practically the same amount of labor would be required to finish, if not exposed to fire or water. Therefore, the additional labor caused by rust or discoloration adds but little if any to the manufacturing cost. Brass, bronze, copper or alloy composition, either rolled or cast, when not warped by heat or its design effected by being crushed, will readily yield to reconditioning, regardless of whether the article is in process or in a completed state.

If the article is stamped sheet metal and has not progressed too far toward completion, deflections from original lines may sometimes be removed by again passing the articles through the stamping press, other damage, such as abrasion and scratches, being removed by the process of grinding, polishing, plating and buffing, which would be necessary to bring the article to a finished state if not exposed to loss by fire.

Restoration of manufacturing tools is usually a question of reconditioning and replacement of parts, and necessary skilled labor to fit same and recondition parts not damaged sufficiently to necessitate replacement.

Wood spinning chucks, solid or in parts, when not charred, even though warped and when placed on the lathe-head or spindle revolve out of true, regardless of any splitting that may take place, are in many cases capable of restoration, which is accomplished by turning the design further down on the same block. It is the aim of the practical chuck maker to allow ample stock to permit of this being done, if for any reason it is desired, as by so doing there is a saving of 75 per cent. to the owner over the original cost.

It is possible that many chucks may have already been subject to this operation a sufficient number of times as to have reached the limit that a particular chuck will stand. It is safe to assume, however, that 75 per cent. of all wood chucks were originally made with this returning in view.

The design of some chucks is such as to make this impossible. Again, it may have been done so many times as to have used up all the stock allowed for this purpose; but it will be found feasible in a large percentage of all wood chucks.

Even though the chucks show evidence of splitting or have actually parted, total loss does not necessarily follow, as in many cases restoration is possible at considerably less than the original cost.

CLEANSING

Copper, brass, zinc and the noble metals are cleaned by the suitable acids which act on them. Such cleaning solutions may be prepared for different metals as follows:

	Water	Nitric	Sulphuric	Hydro-chloric
For copper and brass...	100	50	100	2
Iron	100	3	8	2
Iron (cast)	100	3	12	3
Zinc	100	..	10	..
Silver	100	10	..	..

It is best to make two such solutions, one being reserved for a final dip, during which a strong action occurs upon the surface. As this becomes weaker it can be used for the first cleansing, accompanied by occasional rubbing with sand, etc., according to the nature of the object.

Lead, tin and pewter must not be placed in acid but are cleaned by aid of caustic soda.

In cleansing, different metals usually require a somewhat different treatment. The surface of most metals, when clean, soon become coated with a film of oxide when exposed to the air, especially when the surface exposed is wet, and to avoid this it is necessary to see that they are thoroughly dried.

Before proceeding to cleanse the articles they are usually "trussed" (fastened) with copper wire, to avoid the necessity of handling them during the operation.

The process of using above is the same as the dipping acid referred to below, the only difference being in the substitution of the solution desired in place of that described under the third operation, dipping acid.

COPPER AND COPPER ALLOY CLEANSING SOLUTION

Caustic potash, 1 pound,
Soft water, 1 gallon.

Heat nearly to boiling in a cast-iron pot provided with a cover. Brush to remove any loosely adhering foreign matter, truss, and suspend for a time in the hot lye; usually a few minutes will suffice if the article is not heavily lacquered. If any of its parts are joined with solder it should not be allowed to remain too long immersed, as the caustic liquid attacks solder and their solution blackens copper. On removing rinse thoroughly in running water. If the articles are much oxidized, pickle in a bath composed of:

1 gallon of water,
1 pint of sulphuric acid,

until the darker portion is removed. Rinse in running water and dip in the following solution:

Soft water, 1 gallon,
Cyanide of potassium, 8 ounces.

Remove from the bath and quickly go over every part with a fine brush and fine pumice stone powder moistened with the cyanide solution.

"DIPPING ACID" FOR BRASS, BRONZE OR COMPOSITION

The following process will remove all discoloration and will brighten brass, bronze or composition, and is commonly referred to in electro-plating establishments as "Dipping Acid." The container must be a stoneware vessel (avoid jars with lead glazing) and located in a well-ventilated room and when not in use protect it with a cover of stoneware or glass.

First—Boil in hot potash water of one pound of soda to each gallon of soft water.

Second—Dip and wash in cold running water.

Third—Dip for an instant in a solution of one part nitric acid and two parts oil of vitrol (sulphuric acid).

Fourth—Immediately dip and wash in cold running water.

Fifth—Dip in hot water.

Sixth—Dry in sawdust box.

PICKLING BATH

Cast iron requires to be placed in a cold acid solution for "pickle," to dissolve or loosen the oxide from its surface. The pickle may be prepared in a wooden tub or tank from either of the following formulae:

Sulphuric acid (oil of vitrol), ½ pound.
Water, 1 gallon.

Cast-iron work immersed in this bath, from twenty minutes to one-half hour, will generally have its coating of oxide sufficiently loosened to be easily removed by means of a stiff brush, sand and water. When it is desired that the article should come out of the bath bright, instead of dull-black color which they present when pickled in the plain sulphuric acid bath, the following formula may be adopted:

Sulphuric acid, 1 pound.
Water, 1 gallon.

Dissolve in the above 2 ounces of zinc, which may conveniently be applied in its granulated form. When dissolved add ½ pound nitric acid and mix well.

REMOVING GREASE FROM MACHINERY PARTS

The following method has been substituted for the use of gasolene and other light oils, because of the scarcity of the latter: Boil the parts in caustic soda-lye (1 pound per gallon of water), then brush while the article is still hot. Caustic soda is recommended as better than ordinary soda since it causes the fat or grease to dissolve more quickly.

LEATHER BELTING

Steer hides, from which leather belts are made, after being removed from the animal and thoroughly washed, are placed in vats and treated to a solution of lime and water. This is for the purpose of loosening the hair so that it may be readily removed. Care must be taken not to expose the hide too long in this solution there being danger of burning and depreciating its value for belt purposes.

After the removal of the hair the hides are placed in vats and submerged in water, where they are permitted to remain for a period of time, varying with their thickness, and later washed. This is for the purpose of removing all traces of the lime. After this has been done the hides are placed in one to four solutions of a tanning liquor, progressing in strength, where they remain for four to five months. This is for the purpose of swelling the fiber and increasing its elasticity and strength. It is then dried, and becomes rough leather.

The hides are then trimmed, separating the shoulder, belly and tail parts from the back. The nearer the center of the back of the hide the better the quality of the leather. These centers are soaked in water until soft. The flesh side is then shaved, after which they are laid on long tables where they are scoured with the grain or hair side up. They are then suspended and semi-dried, and later treated to a process termed "dubbing," which consists of an application of a composition of codfish oil and mutton tallow, the viscosity and consistency of which is approximately that of vaseline. This is applied thoroughly to both sides. The stock is then hung up in a warm room to allow the grease to soak into the fiber.

While this explanation of the tanning process is brief it is sufficient for the purpose of this paper and is intended to show the liberal use of water in the process of tanning leather for belt and other purposes.

The leather is then placed under a severe strain in stretching frames where it remains for about 24 hours, just under the breaking point. This part of the process requires great care, as too great a strain removes the elasticity of the fiber and makes the leather unsuitable for belt purposes. It is essential that leather belts have a certain amount of elasticity in the absence of which the belt will break and tear. The fact that leather belts possess this elasticity and give and take according to the atmosphere is an advantage claimed by leather-belt manufacturers over that of rubber and fabric belts. Its ability to give and take gives to leather belts in use a greater life than used belts that are permitted to be idle for an indefinite length of time.

To be serviceable, leather belts must possess a certain amount of oil or lubricant, in order to be pliable. This grease, when the belts are subject to a wetting, is washed out, moisture taking its place, which later evaporates, causing the leather to resume its original hardness. Its pliability and life can be restored by the above treatment.

The life of leather belts, that possessed any virtue previous to being wet and then dried, can be restored by the use of the above-described preparation of codfish oil and mutton tallow. If the belts have suffered repeated wettings and dryings and have become exceedingly hard, an excellent treatment is to run the belt at the rate of about ten feet per minute through a tank filled with tanner's oil, which is thinner than cod oil and mutton tallow and is heated to a temperature between 140 and 150 degrees. Care must be taken not to exceed the maximum temperature of 150 degrees F.

As an instance of leather-belt restoration, will cite the case of the sinking of a grain elevator possessing a large value in leather belts which was submerged in New York for two weeks. When raised the belts were removed to the factory of a prominent belt manufacturer of New York City, where restoration took place and later the same belts were again placed in service in the same elevator, in a condition equal to that of the day previous to sinking, at an approximate cost of 25 per cent. of the replacement value, plus a further cost of approximately 10 per cent. for replacing wastage due to tearing of laps while being separated, preparatory to restoration and reinstalling.

At this time it is worthy of note that salt water is more injurious to leather than fresh water.

To restore leather belts suffering from a wetting that has not been sufficient to separate the belt layers or laps, first thoroughly clean, removing all dirt, then apply castor or neatsfoot oil to both sides of the belt, using a rag or bristle brush, giving a light coat to the face and a heavier one to the back, spreading evenly. In the event of the belt getting too much of either of the above, the belt will become too soft and will slip; but this is

From a paper read by John Hankin before the Insurance Society of New York.

only a temporary annoyance and it will adjust itself after being in use a short time.

Leather belts that have become saturated with oil may be restored by a surface washing of ammonia, naphtha or gasoline.

A belt dressing that is good for leather belts is not good for rubber or fabric belts.

Machine oils, soap or rosin are injurious to belts and should not be used.

The grain side of leather belts is the hair side.

Extreme water damage only to leather belts may be fixed at approximately 25 per cent. of the replace value, plus freight and cartage to any competent leather-belt manufacturer, and the added cost of approximately 10 per cent. for loss in length of belt due to tearing where laps have to be forcibly separated.

LEATHER BELTING "WATERPROOFED"

Leather belts that have been cemented with waterproof cement and treated to a waterproofing process are not damaged by any exposure to wetting, regardless of how received, the loss from water only being limited to the cost of cleaning and applying a proper belt dressing and reinstallation, which, except under abnormal conditions, would be approximately 10 per cent. of its replacement value. Reference to bills will indicate if belts are waterproof. All waterproof belts are stamped with a steel die, waterproof.

RUBBER BELTS

Rubber belts are especially designed to withstand water and consequently are impervious to damage from that cause. The gum rubber entering into their construction is very susceptible to damage by heat, which is difficult of restoration. Loss, if any, by heat can only be based on decreased length of useful life.

FABRIC BELTS

What has been said of rubber belts largely applies to fabric belts except that not all fabric belts are waterproof. Waterproof belts are guaranteed against exposure to all weather conditions, steam and acid fumes (except nitric acid), water in any quantities and a constant temperature of 100 to 150 degrees F., and intermittent temperature considerably in excess of those quoted.

ELECTRIC MOTORS AND GENERATORS

Where carbonization has occurred, rewinding of the carbonized portions will be necessary, the loss varying with the extent of the carbonization, which, however, may effect each field separately, without necessarily damaging adjoining fields. While damage to the armature does not necessarily mean a corresponding damage to the fields, or vice versa, the construction of the armature is such as to make it difficult to carbonize one portion or segment without making complete rewinding of armature a necessity.

When the damage is confined to smoke and water only reconditioning is not difficult and is accomplished by a thorough cleaning, baking and, in extreme cases, reshellacking or varnishing.

In cases where motors and generators have been subjected to immersion in salt or filthy water, an excellent method is to give them a thorough washing by the use of fresh water through a hose and under high pressure, after which give the units a thorough cleaning, baking and varnishing

The following extract from a letter by J. H. Bryan, of Dayton, Ohio, published by *The American Machinist*, in their issue of September 4, 1913, will be of interest at this time:

"CLEANING UP A FACTORY AFTER THE GREAT DAYTON FLOOD

"The subject of this article is a large Dayton manufacturing concern, located along the banks of the Mad River, a tributary of the great Miami River.

"The high-water marks over the entire plant averaged 12 feet, submerging the power plant and some 200 motors. March 29 the waters receded, leaving in the various shops a deposit of 5,000 tons of slimy mud that had the bulldog tenacity for clinging to things, in addition to an acid property that was very destructive of steel and iron finished work.

"In order to retain and give the shop organization employment the whole force of 700 men were employed without reduction of wages to remove the muck from buildings and machinery and to make repairs incident to the flood. In the power plant a boiler and a small engine were soon got in readiness to operate the only dry motor in the works, as a generator to furnish power temporarily for cranes to transfer motors to a central point for drying.

"The program for drying motors and generators was as follows: Suitable horizontal steam-jacketed tanks were provided, with a table moved on rollers inside of the tank for loading purposes, and the field coils and armatures were placed in these tanks and subjected to a temperature of 170 degrees F. and 27 inches of vacuum for 48 consecutive hours. At the expiration of this time a large percentage of these parts were found O. K., and those parts that showed a ground were reheated. The large generators, with armatures built on crankshafts of engines were liberally supplied with steam coils, especially at the bottom of the field ring, and the whole of the generator and steam coils boxed in with dry lumber as it was found that planking was far more satisfactory than metal owing to the fact that the lumber would absorb moisture while with a plate-steel oven the interior surfaces would continually run water on account of the low temperature.

"The generators were subject to a temperature of 140 degrees F. for 36 consecutive hours and were then ready to be tested out. If no difficulties were experienced, it was fair to presume the generators were in good condition. However, in such cases it is well before the generators are put in commission to carry full load to run them light for five hours or more.

"The generators and motors were all dried out as noted above and only two motors in the whole lot gave trouble in operation.

"While these important members were receiving attention, the machine tools and all the manufactured product were taken apart and scrupulously cleaned as the mud when dried and pulverized was a good substitute for flour of emery."

Seditious Publications in the Public Library

THE attitude which librarians should assume towards material treating of the war in such a way as might tend to encourage disloyalty among readers is possibly the most important issue now facing the profession There are probably in every public library such publications as are referred to in the following: "In the public library at * * * are numerous pamphlets and newspaper clippings containing untruths, half truths and wrong conclusions calculated, it is held, to spread German propaganda, create sympathy for Germany and furnish encouragement to disloyalty among Americans. Their presence leads to the conclusion that in other public libraries throughout the country similar papers may be found serving the cause of the enemy. Discovery of the * * * situation has led, in fact, to steps which have been taken with a view to bringing about a general survey of libraries in the United States, and a determined effort to eliminate German propaganda of this sort. Inasmuch as the United States Government has refused the mail privileges to literature of this sort it is held that city officials everywhere should prevent libraries from being used in this way."

The handling of propaganda literature in the public library has long been the subject of professional discussion more or less academic in its character. The profession has not yet announced any definite principles which must be adhered to as to propaganda in general. There is, however, no room for dispute or even discussion as to the treatment of material which approaches the point of disloyalty to the country in times of war. All questionable material must be eliminated.

Any book or publication containing material the reiteration or republication of which might be considered seditious, should be summarily withdrawn from circulation. It must be remembered that the public library, supported by public funds, is an integral part of that government which is at war with the Central Powers. Librarians are government employees. They cannot assume aloofness nor can they be considered as academically neutral. Both institution and individual have a distinct duty to the government of which they are a part. There is therefore upon each public library a high responsibility to see that it is not made an instrumentality for the promulgation of propaganda which might in any way encourage disloyalty. In handling periodicals even greater care must be observed since they are more often than books employed to advance ideas having a tendency toward disloyalty.

The library must be above suspicion.—*Wisconsin Library Bulletin.*

Peanut Oil in France

ACCORDING to the official figures there were treated at Marseilles during the year 1912 over 120,000 (long) tons of unshelled peanuts and about 240,000 shelled, and these quantities of raw material furnished 58,700,000 liters (15,000,000 gallons) of comestible oil and 87,000,000 liters (22,000,000 gallons) of oil for other uses. During the same year, 62,383 tons of peanuts were imported into Germany in which country they are used almost exclusively for oil production. In France the peanut oil, which comes from pressing by the cold process is used for alimentary purposes, then a second process is used consisting in pressing the pommace with cold water, but this product is inferior and can only be employed for lubrication or for lighting purposes. Still a third pressure is used by a hot process and this yields an oil which is of use in soap manufacture. The comestible oil is used in large quantities in different countries and especially in Holland, for preparation of imitation butter products. The oil cake resulting from the pressing process is of considerable value, for it furnishes an excellent food for stock, and another use for oil cake is as a fertilizer. Sometimes the shells are ground up and mixed with the oil cake, but this reduces the alimentary value. As a general rule the peanut shells are utilized as fuel in the oil mills themselves.

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